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Publication date:
1975

Document Version
Publisher's PDF, also known as Version of record

Risø Report No. 323

Danish Atomic Energy Commission

Research Establishment Risø

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June 1975

Sales distributors: Jul. Gjellerup, 87, Sølvgade, DK-1307 Copenhagen K, Denmark

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UDC 614.73 (4[illegible])

Environmental Radioactivity in Denmark in 1974

by

A. Aarkrog and J. Lippert

Danish Atomic Energy Commission
Research Establishment Risø
Health Physics Department

Abstract

The present report deals with the measurement of fall-out radioactivity in Denmark in 1974. Strontium-90 was determined in samples from all over the country of precipitation, soil, ground water, sea water, grass, dried milk, fresh milk, grain, bread, potatoes, vegetables, fruit, total diet, drinking water, and human bone. Furthermore, ^{90}Sr was determined in local samples of air, rain water, grass, sea plants, fish, and meat. Caesium-137 was determined in soil, sea water, milk, grain products, potatoes, vegetables, fruit, total diet, fish, and meat. It was also measured by wholebody-counting of a control group at Risø. Estimates of the mean contents of radiostrontium and radiocaesium in the human diet in Denmark during 1974 are given. The γ-background was measured regularly at locations around Risø, at ten of the State experimental farms, in one area in Zealand, one in Jutland, and along the shores of the Great Belt. Finally the report includes routine surveys of environmental samples from the Risø area.

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ABBREVIATIONS AND UNITS

FP	fission products
pCi	picocurie, 10^{-12} Ci, $\mu\mu$Ci
nCi	nanocurie, 10^{-9} Ci, $m\mu$Ci
mCi	millicurie, 10^{-3} Ci
MPC	maximum permissible concentration
c/min	counts per minute
d/min	disintegrations per minute
c/h	counts per hour
μR	micro-roentgen, 10^{-6} roentgen
S.U.	pCi ^{90}Sr/g Ca
O.R.	observed ratio
M.U.	pCi ^{137}Cs/g K
V	vertebrae
m	male
f	female
nSr	natural (stable) Sr
eqv. μg U	equivalents μg uranium: activity as from 1 μg U ($\sim$90 d/h)
eqv. mg KCl	equivalents mg KCl: activity as from 1 mg KCl ($\sim$0.88 d/min)
S.D.	standard deviation: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{(n-1)}}$
S.E.	standard error: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{n(n-1)}}$
U.C.L.	upper control level
L.C.L.	lower control level
σ	one standard deviation due to counting
S.S.D.	sum of squares of deviation: $\Sigma(\bar{x}-x_i)^2$
f	degrees of freedom
s^2	variance
v^2	ratio between the variance in question and the residual variance
P	probability fractile of the distribution in question
η	coefficient of variation, relative standard deviation
anova	analysis of variance
A	relative standard deviation 20-33%
B	relative standard deviation > 33%, such results are not considered significantly different from zero activity

Samples:

H:	sea water
J:	soil
L:	air
B:	bed soil
Å:	eel
PG:	grass
PH:	sea plants
D:	drain water
S:	waste water
R:	precipitation
M:	milk

1. INTRODUCTION

1.1.

The present report is the eighteenth of a series of periodic reports (cf. ref. 1) dealing with measurements of radioactivity in Denmark. The programme is unchanged as compared with 1973.

1.2.

The methods of radiochemical analysis[2-4] and the statistical treatment of the results[5] are still based on the principles established in previous reports[1].

1.3.

The report does not include detailed tables of the total β-measurements from the environmental control of the Risø site. These tables are available in the form of microcards at the library of the Danish Atomic Energy Commission at Risø.

1.4.

The report contains no information on sample collection and analysis except in the cases where these procedures have been altered.

1.5.

In 1974 the personnel of the Environmental Control Section of the Health Physics Department consisted of one chemist, ten laboratory technicians, two sample collecters, and two laboratory assistants. The Section for Electronics Development continued to give assistance in the maintenance of the counting equipment and in the interpretation of the γ-spectra. The program (cf. 2) used in the calculations of ^{90}Sr and the γ-analysis, as well as the program for data treatment, were developed by this section.

1.6.

The composition of the average Danish diet used in this report is identical with that proposed in 1962 by Professor E. Hoff-Jørgensen, Ph. D.

2. ORGANIZATION AND FACILITIES[1, 6, 7, 8)

Three Ge(Li)-detectors, each connected to a 1024-channel analyzer, are available. An 8 inch NaI(TL)-detector used for whole-body measurements and four detectors for alpha spectrometry are connected to a fourth 1024-channel analyzer.

A computer program, STATDATA 16, is available for the treatment of the results of this report (and the results of several other projects). The program checks and stores the data, produces lists, tables and plots and calls separate programs for analysis of variance and regression, etc. The principle for registering the data is the assignment of 6 parameters to each result or set of multiple results. These parameters are:

Isotope (or code for γ-background, etc.)
Sampling date
Sample type
Sampling location
Quality of measurement (relative standard deviation)
Unit of results

followed by:

Number of results
Results.

To date approximately 23000 sets of results have been registered covering the period from 1957. However, a similar number of results still remains unregistered.

3. ENVIRONMENTAL MONITORING AT TISØ IN 1974

3.1. Gross β-Activity

3.1.1. Sea Water

Fig. 3.1.1.1 shows the sample locations in Roskilde Fjord. Fig. 3.1.1.2 shows the control chart for H I. The yearly mean for H I in 1974 was 53 eqv. mg KCl/2.5 g (in 1973: 55), for H III-VI: 53 eqv. mg KCl/2.5 g (in 1973: 55) and for H VII-X: 53 eqv. mg KCl/2.5 g (in 1973: 56). Fig. 3.1.1.3 shows the mean levels of radioactivity in sea salt since 1957.

Fig. 3.1.1.1. Roskilde Fjord.

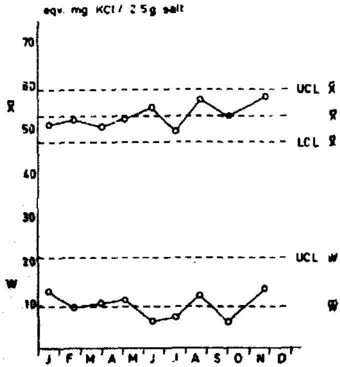


Fig. 3.1.1.2. Control chart for HI, 1974.

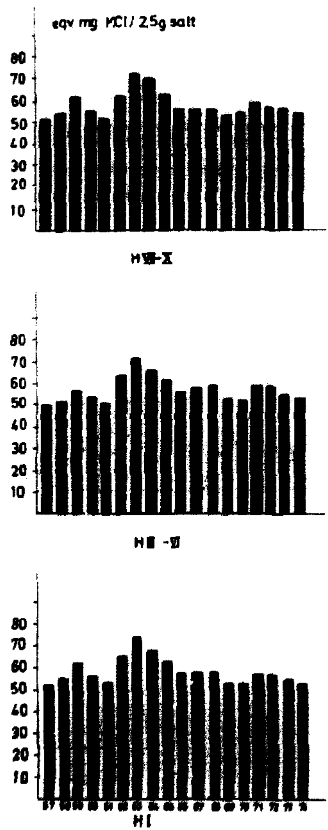


Fig. 3.1.1.3. Mean radioactivity in sea water 1957-74.

3.1.2. Soil

No soil samples from the environment of Risø were measured for total β-activity in 1974.

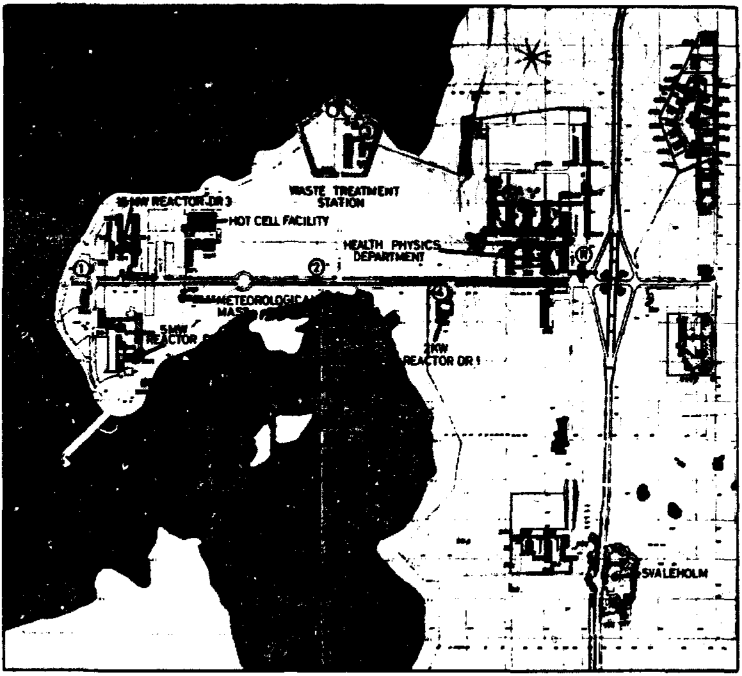


Fig. 3.1.2.1. The Risö Research Establishment.

3.1.3. Air

Fig. 3.1.3.1 shows the diagram for FP activity in air samples in 1974. The mean value for the year was 0.11 eqv. mg KCl/m^3 as compared with 0.08 eqv. mg KCl/m^3 in 1973.

Fig. 3.1.3.2 shows the mean FP levels in air since 1957.

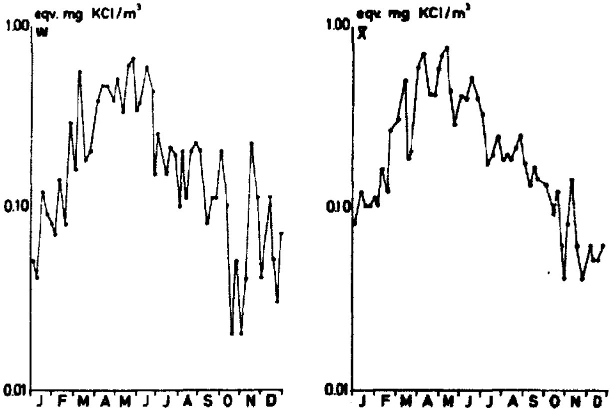


Fig. 3.1.3.1. Control chart for LF, 1974.

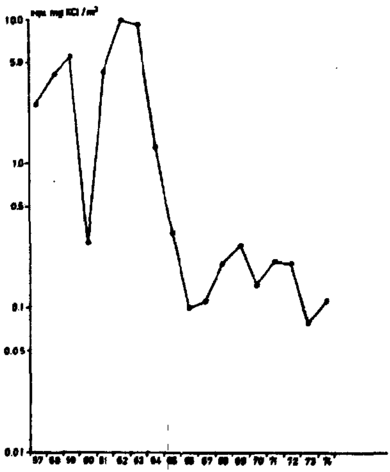


Fig. 3.1.3.2. Mean radioactivity in air, 1957-74.

3.1.4. Bed Soil From the Fjord

The mean activity in bed soil B I was 129 eqv. mg KCl/3.0 g ash in 1974 as compared with 160 eqv. mg KCl/3.0 g in 1973. Fig. 3.1.4.1 shows the mean levels for B I since 1957 (cf. also 3.4).

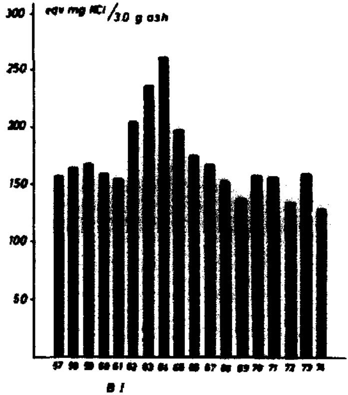


Fig. 3.1.4.1. Mean radioactivity in bed soil, 1957-74.

3.1.5. Fish

No fish samples from Roskilde Fjord were measured for total β-activity in 1974.

3.1.6. Grass

The mean values were in 1974 for PG I: 11 eqv. mg KCl/0.1 g grass ash (in 1973: 7), for PG II-III: 11 eqv. mg KCl/0.1 g (in 1973: 4) and for PG IV-V: 13 eqv. mg KCl/0.1 g (in 1973: 14). Fig. 3.1.6.1 shows the mean activities in grass ash since 1957.

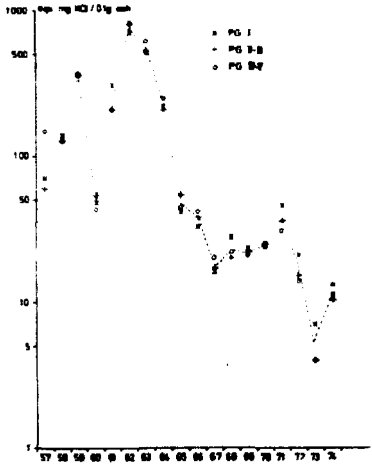


Fig. 3.1.6.1. Mean FP-radioactivity in grass ash, 1957-74.

3.1.7. Sea Plants

The mean FP level in 1974 in Fucus vesicolosus (PH I) was 4 eqv. mg KCl/0.1 g ash (12 in 1973). In Zostera marina (PH III-IX) we found 5 eqv. mg KCl/0.1 g ash in 1974 (2 in 1973).

3.1.8. Fresh Water

Fig. 3.1.8.1 shows the control chart for S (cf. fig. 3.1.2.2). The yearly means for D I, D II, D IV, and S in 1974 were 40 eqv. mg KCl/l (1973: 49), 19 eqv. mg KCl/l (1973: 14), 43 eqv. mg KCl/l (1973: 38), and 31 eqv. mg KCl/l (1973: 31) respectively. Fig. 3.1.8.2 shows the activity in drainage water (D) and sewage water (S).

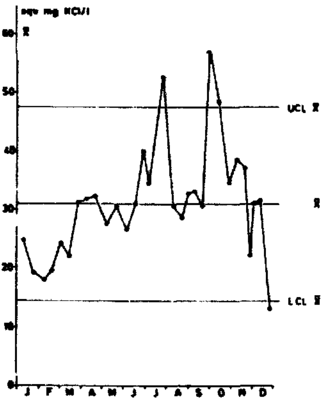


Fig. 3.1.8.1. Control chart for sewage water (S), 1974.

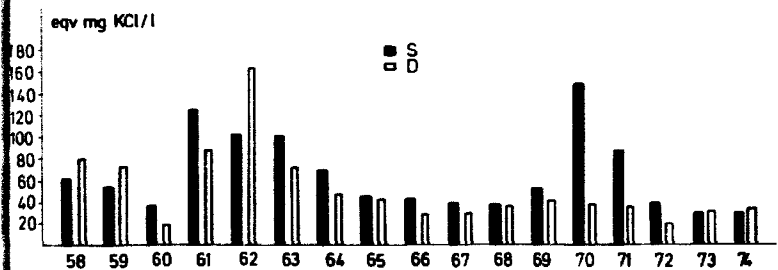


Fig. 3.1.8.2. Mean radioactivity in fresh water, 1958-74.

3.1.9. Rain Water

Figs. 3.1.9.1 and 3.1.9.2 show the specific FP level in and the total fall-out from rain water collected daily at Risø in 1974. The total fall-out in 1974 was measured at $0.028 \cdot 10^6$ eqv. mg KCl/m^2, and the annual mean concentration in rain water at Risø was 49 eqv. mg KCl/l. In 1973 the corresponding figures were $0.017 \cdot 10^6$ and 67 respectively.

Fig. 3.1.9.3 shows the specific activity in rain water since 1957.

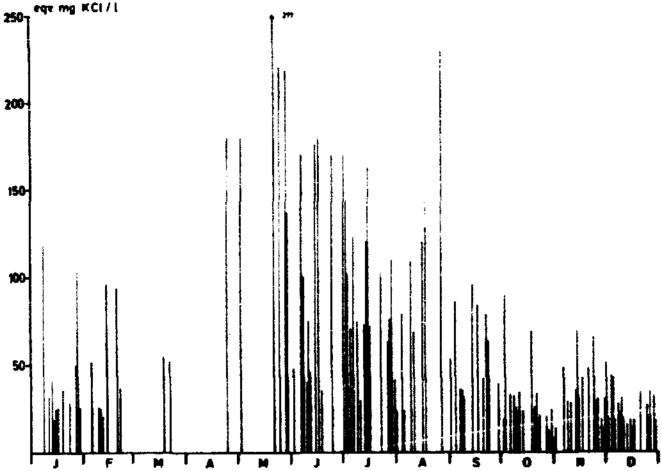


Fig. 3.1.9.1. Concentration of β-activity in precipitation in 1974.

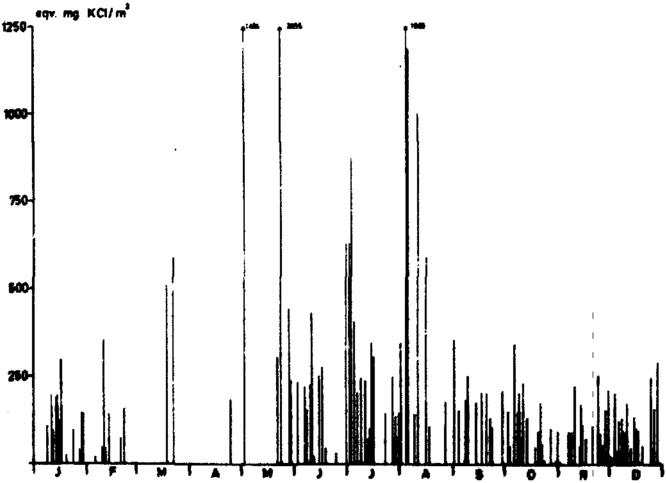
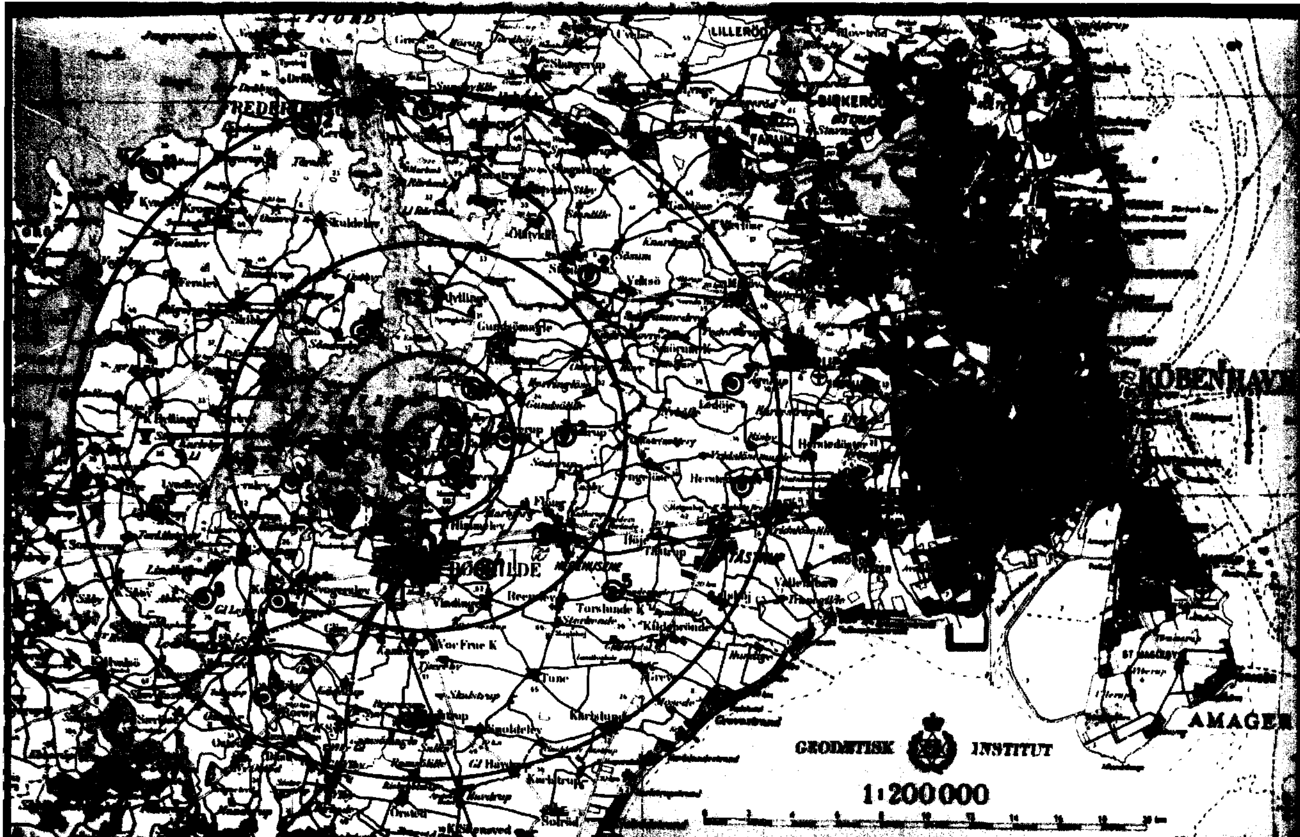


Fig. 3.1.9.2. Total fall-out from precipitation in 1974.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Torslunde K
Vor Frue K
GEODÆTISK INSTITUT
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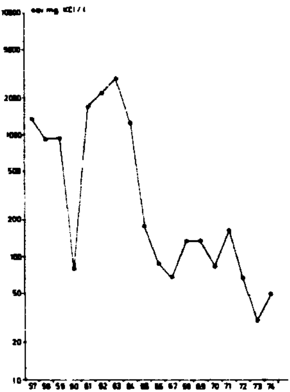

Fig. 3.1.9.3. Specific activity in precipitation, 1957-74.

3.2. Radiochemical β-Analysis

3.2.1. Air

The "big air sampler" described in Risø Report No. 23[1] has a shunt through which the air volume is determined. As in the three previous years, both the shunt filter (I) and aliquots cut out from the main filter (II) were analysed to see whether activity levels were identical in the two filters. As I/II = 1.05 ± 0.17 (1 SE), we still concluded that the two filters showed the same levels. The mean air activity level for 1974 is reported as the mean of the glass-fibre filter collection and the daily paper filter sampling: 1.43 ± 0.12 pCi $^{90}Sr/10^3\ m^3$, i.e. 3.7 times the 1973 level. The mean peak activity of the three collections in 1974 was measured in May to be 3.6 pCi $^{90}Sr/10^3\ m^3$.

Fig. 3.2.1.1 shows the ^{90}Sr levels in air since 1957.

Table 3.2.1.1

Strontium-90 in air collected at Risø in 1974
pCi ^{90}Sr/10^3 m^3

Month	Daily air filters Paper	Monthly air filters (glass-fibre filters) I	 II
Jan.	0.35	0.40	0.46
Feb.	[illegible]	0.38	1.0[illegible]
Mar.	1.26	-	1.17
Apr.	2.6[illegible]	2.77	2.70
May	3.27	-	3.43
June	2.92	-	3.40
July	1.46	-	1.56
Aug.	1.16	-	1.24
Sep.	0.74	0.81	0.66
Oct.	0.44	0.39	0.33
Nov.	0.35	0.35	0.34
Dec.	0.45	0.34	0.19
1974	1.37	-	1.36

I: are the normally used [illegible] filters.

II: are aliquots cut out from the main filters also used for ^{137}Cs determination (cf. table 3.[illegible].1).

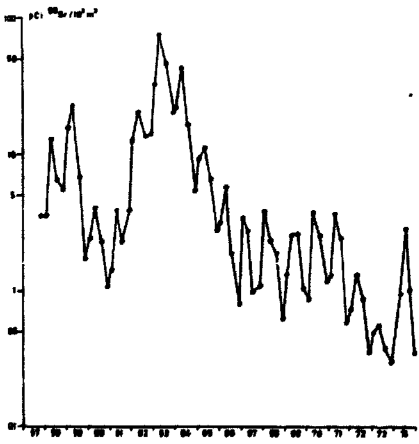

Fig. 3.2.1.1. Quarterly ^{90}Sr levels in air, 1957-74.

3.2.2. Grass

Table 3.2.2 shows the ^{90}Sr content in grass ash from Zealand in 1974. The mean ^{90}Sr activity was 2.8 pCi $^{90}Sr/g$ ash or 47 S.U. as compared with 2.1 pCi/g ash or 34 S.U. in 1973, i.e. the 1974 level was approx. 35% higher than the 1973 level. Fig. 3.2.2.1 shows the ^{90}Sr levels in grass since 1957.

[illegible]

[illegible]

	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Apr.-[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Mean	[illegible]	[illegible]	[illegible]

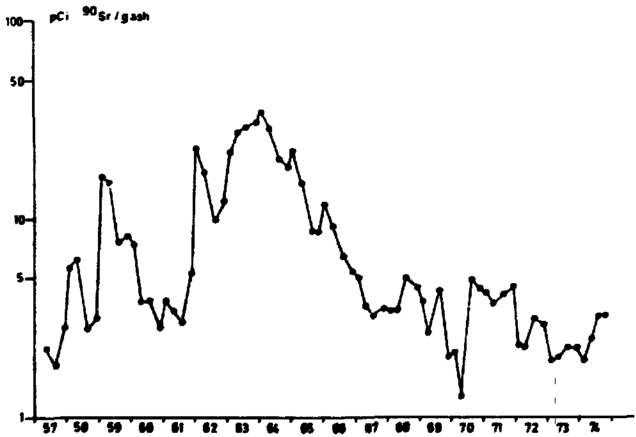

Fig. 3.2.2.1. Quarterly ^{90}Sr levels in grass ash, 1957-74.

3.2.3. Sea Plants

Fig. 3.2.3 shows the S.U. levels in sea plants since 1959 and table 3.2.3 the results for 1974. The level in Fucus vesicolosus was 19 pCi ^{90}Sr/g Ca, and in Zostera marina 2 pCi ^{90}Sr/g Ca.

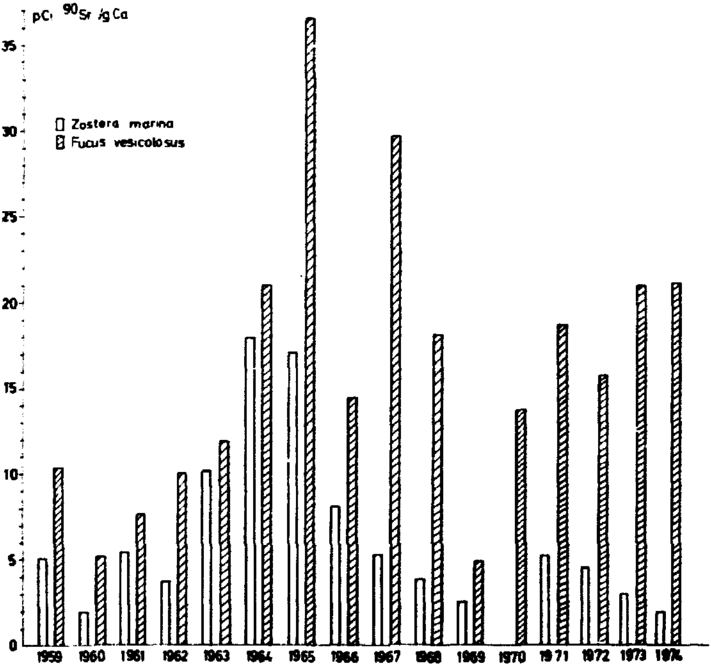

Fig. 3.2.3. Strontium-90 in sea plants from Roskilde Fjord, 1959-74.

Table 3.2.3

Strontium-90 in sea plants from Roskilde Fjord in 1974

	Location	Species	pCi ^{90}Sr/g Ca	pCi ^{90}Sr/g ash	mg Sr/g Ca
June	pH III	Zostera marina	1.97	0.12	5.0
June	pH IX	Zostera marina	2.54	0.34	5.0
June	pH I	Fucus vesicolosus	27.6	1.37	25
Nov.	pH I	Fucus vesicolosus	9.6	1.06	32.3
Nov.	pH IX	Zostera marina	1.93	0.42	6.3

Table 3.2.4.1

Strontium-90 in rain water collected in rain bottles at Risø in 1974 (sampling area 0.2?6 m^2)

Month	mm	pCi $^{90}Sr/l$	mCi $^{90}Sr/km^2$
Jan.-Mar.	108	0.41	0.272
Apr.-June	66	0.26	0.149
July-Sep.	195	0.87	0.17[illegible]
Oct.-Dec.	186	0.33	0.061
1974	555	1.17	0.657

$$\bar{X}\ pCi/l = \frac{\Sigma\ mCi/km^2 \cdot 10^3}{\Sigma\ mm}$$

3.2.4. Rain Water

Table 3.2.4.1 shows the quarterly radiostrontium level in rain water collected at Risø in 1974. The total ^{90}Sr fall-out in 1974 was 0.65 mCi $^{90}Sr/km^2$ (555 mm precipitation), and the mean concentration in the rain water was 1.17 pCi $^{90}Sr/l$. In 1973 we measured 0.10 mCi $^{90}Sr/km^2$ (551 mm precipitation) and 0.18 pCi $^{90}Sr/l$, i.e. the 1974 ^{90}Sr levels were 6.5 times the 1973 figures.

Fig. 3.2.4.1 shows the ^{90}Sr levels in rain water since 1959.

At five sampling locations (1-5) in zone I (cf. fig. 3.1.2.1) ion-exchange columns were used to collect monthly samples of precipitation together with the bottle collectors. These columns have been described earlier (Risø Report No. 41[1]) and are similar to those used in the U.S.A. by HASL[4].

Our intention was to compare the efficiency of the ion-exchange columns to collect fall-out with that of the rain bottles. Table 3.2.4.2 shows the results. The total amount of ^{90}Sr fall-out in 1974 measured by the 2 systems was: 0.65 and 0.43 mCi $^{90}Sr/km^2$ respectively.

Figures 3.2.4.2 and 3.2.4.3 show comparisons between the different sampling systems for ^{90}Sr in precipitation. It appears that the specific activity in pCi $^{90}Sr/l$ is not systematically different for the 3 sampling systems. We may further conclude that the rain bottles and the ion-exchange collectors at Risø show no significant difference as regards efficiency of collecting ^{90}Sr from precipitation.

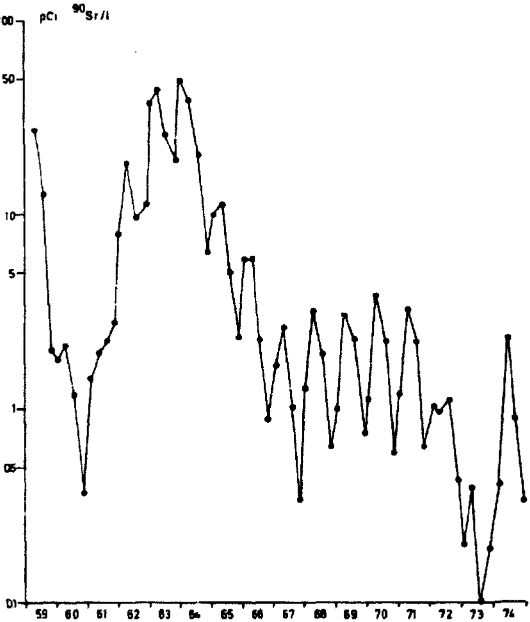

Fig. 3.2.4.1. Quarterly ^{90}Sr levels in precipitation, 1959-74.

Table 3.2.4.7

Strontium-90 in rain water collected in ion-exchange column collectors at Risø in 1974 (sampling area 0.325 m^2)

Month	mm	pCi ^{90}Sr/l	mCi ^{90}Sr/km^2
Jan. - Mar.	92	0.51	0.047
Apr. - June	51	2.41	0.123
July - Sep.	178	0.57	0.101
Oct. - Dec.	198	0.82	0.162
1974	Σ 519	$\bar{x}$ 0.83	Σ 0.433

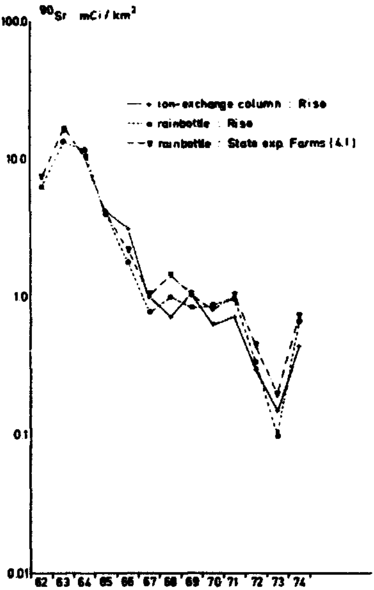

Fig. 3.2.4.2. Strontium-90 fall-out measured by 3 different sampling systems 1962-74.

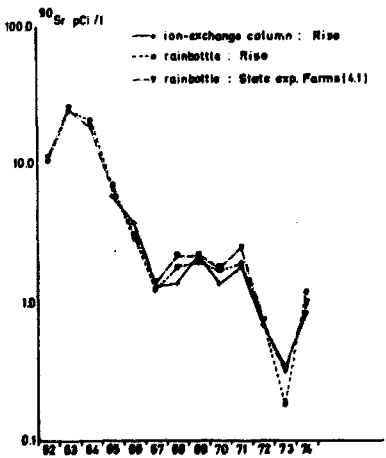

Fig. 3.2.4.3. The specific ^{90}Sr activity in precipitation collected by 3 different sampling systems 1962-74.

3.2.5. Milk from a Farm near Risø

Table 3.2.5 shows the radiostrontium and ^{137}Cs contents in milk collected in 1974 from a farm near Risø. The mean level was 2.2 S.U. as compared with 2.3 S.U. in 1973. Figure 3.2.5 shows the ^{90}Sr levels in "Risø" milk since 1959. The caesium-137 mean level was 2.8 pCi/l as against 2.9 pCi/l in 1973.

Table 3.2.5

Strontium-90 and Caesium-137 in milk from Risø* in 1974

Month	pCi ^{90}Sr/g Ca	pCi ^{137}Cs/g K	pCi ^{137}Cs/l
Jan. - Mar.	2.36	1.42 A	2.37 A
Apr. - June	2.07	1.17 A	1.97 A
July - Sep.	2.02	3.04	5.09
Oct. - Dec.	2.42	1.19 A	1.95 A
1974	2.21	1.70	2.84

*The milk was collected from the milk-producing farm nearest to Risø

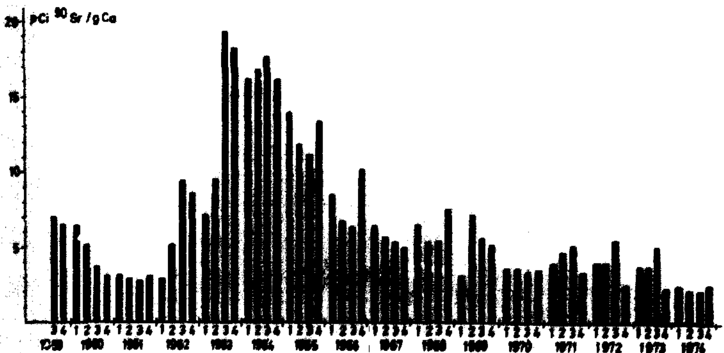

Fig. 3.2.5. Quarterly ^{90}Sr levels in milk from the Risø neighbourhood 1959-74.

3.3. γ-Spectroscopy of Air Samples

As in 1962-1973, samples of air were collected twice a week by means of the air sampler described in Risø Report No. 23[1]. The filters were measured on a 30 cm^3 Ge(Li) detector[8]. Table 3.3.1 shows the monthly means of the ^{137}Cs determinations. The peak value was observed in May (cf. also ^{90}Sr in air, table 3.2.1). The mean level in 1974 was 4.2 times higher than the 1973 mean. The $^{137}Cs/^{90}Sr$ ratio in air filters was 1.4 in 1974 as compared with 1.2 in 1973.

Figures 3.3.2 - 3.3.4 show some fission product ratios in ground level air compared with the theoretical decay curves calculated from the data in HASL-300[4], and assuming that all the activity was created by the Chinese test explosion of June 27, 1973 (No. XV). The figures show that the observed ratios in general fall a little below the theoretical curves. From fig. 3.3.3 we estimate the amount of old ^{137}Cs, i.e. ^{137}Cs created before June 27, 1973, to be approx. 15% of the total amount of ^{137}Cs present in surface air in the first half of 1974.

Table 3.3.1

Caesium-137 in glass-fibre air filters collected twice a week at Risø in 1974

Month	pCi $^{137}Cs/10^3 m^3$
Jan.	0.60±0.08
Feb.	1.11±0.15
Mar.	2.33±0.17
Apr.	3.62±0.48
May	5.04±0.50
June	4.32±0.44
July	2.32±0.44
Aug.	1.66±0.11
Sep.	1.01±0.08
Oct.	0.51±0.07
Nov.	0.44±0.07
Dec.	0.52±0.04
1974	1.96

The error term is the S.E. of the mean of the activity found in 8 or 9 filters collected during a month.

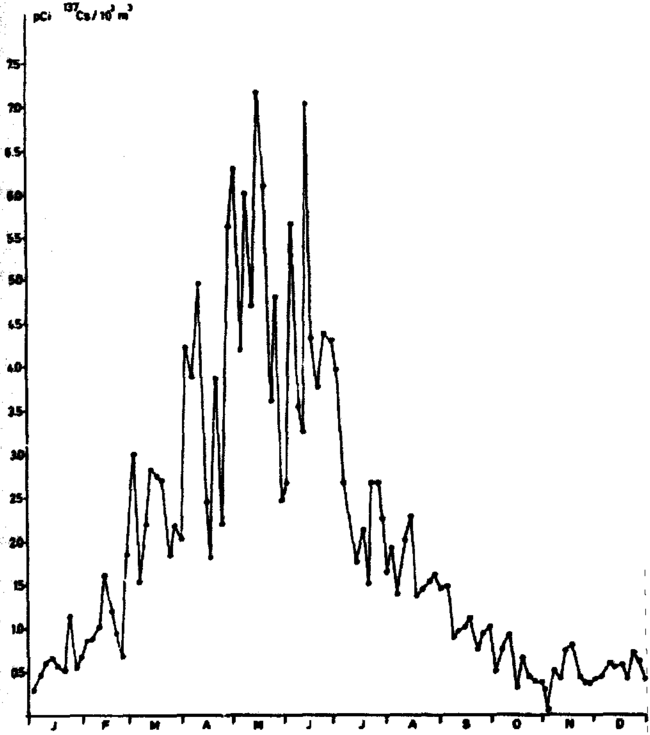

Fig. 3.3.1. Caesium-137 in ground level air at Risø in 1974.

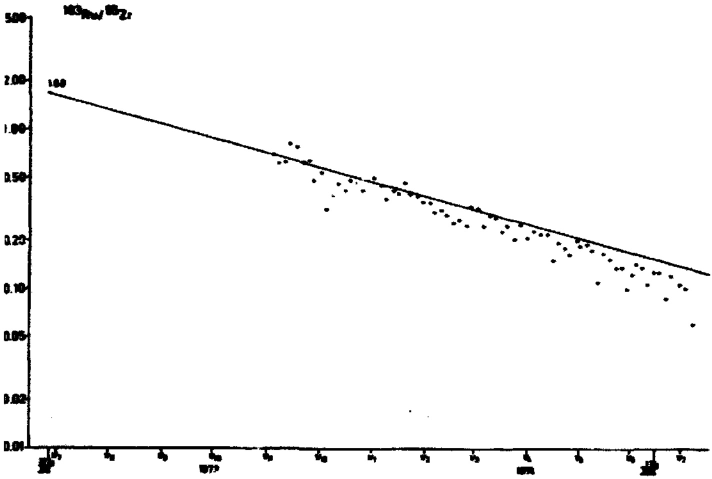

Fig. 3.3.2. The theoretical decay curve of the $^{103}Ru/^{95}Zr$ ratio from the Chinese nuclear test on June 26, 1973, compared with the measured ratios in ground level air at Risø, 1973-74.

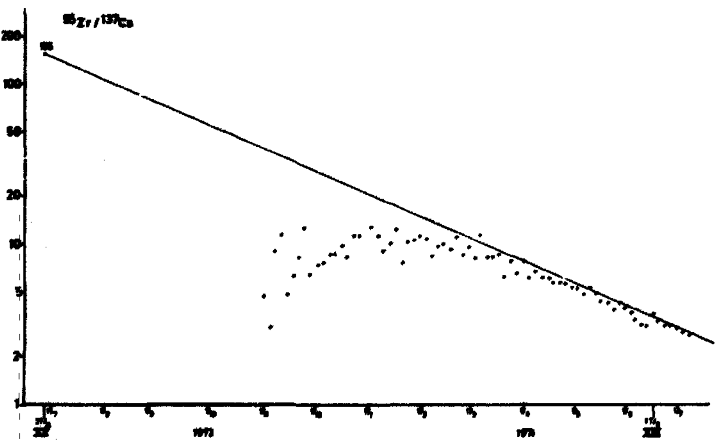

Fig. 3.3.3. The theoretical decay curve of the $^{95}Zr/^{137}Cs$ ratio from the Chinese nuclear test on June 26, 1973, compared with the measured ratios in ground level air at Risø, 1973-74.

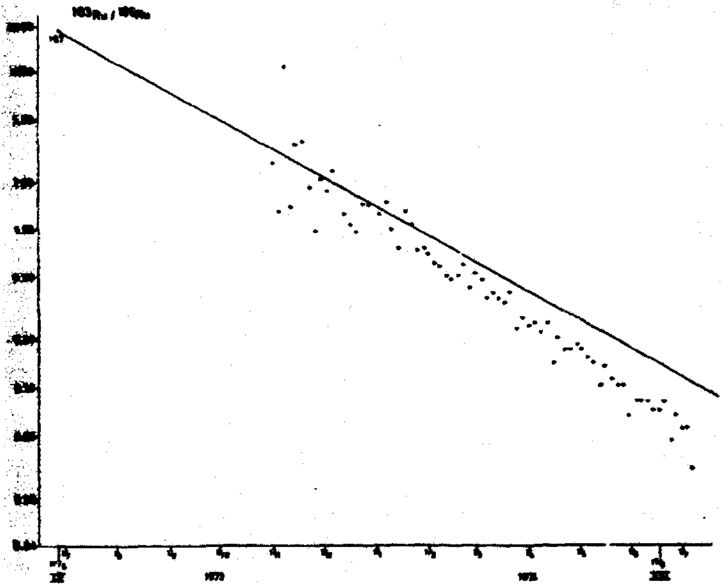

Fig. 3.3.4. The theoretical decay curve of the $^{103}Ru/^{106}Ru$ ratio from the Chinese nuclear test of June 26, 1973, compared with the measured ratios in ground level air at Risø 1973-74.

3.4. γ-Spectroscopy of Bed Soil Samples from Roskilde Fjord

North of the outlet from the Waste Treatment Station (fig. 3.1.2.1), bed soil samples have been collected with a van Veen sampler since 1972. Aliquots of approx. 2 kg were analysed by Ge(γ) spectrometry. Table 3.4.1 shows the results which are equal to those in 1972 and 1973.

Table 3.4.1

Caesium-137 in bed soil collected in Roskilde Fjord in 1974. (Van Veen sampler)

	pCi ^{137}Cs pCi/kg
17/4	395
July	263
26/9	384
29/10	460
Mean±1 S.E.	376±41

4. RADIOSTRONTIUM AND RADIOCAESIUM IN PRECIPITATION, SOIL, AND GROUND WATER IN DENMARK IN 1974

4.1. Strontium-90 in Precipitation

Samples of rain water were collected in 1974 from the ten State experimental farms (cf. fig. 4.1.1) in accordance with the principles laid down in Risø Report No. 63, p. 51[1].

Table 4.1.1 shows the results of the ^{90}Sr determinations and tables 4.1.2 and 4.1.3 the analysis of variance of the results. The variation with time was highly significant (P > 99.95%). The maximum fall-out occurred in May-June, when the mean content in precipitation was 4.38 pCi $^{90}Sr/l$ (cf. also the air measurements in 3.2.1) and the mean fall-out rate was 0.230 mCi $^{90}Sr/km^2$. Tables 4.1.2 and 4.1.3 show that the variation between locations was significant only in the case of mCi $^{90}Sr/km^2$. The mean levels for ten State experimental farms were 0.71 mCi $^{90}Sr/km^2$ and 0.98 pCi $^{90}Sr/l$. In Appendix A the country mean level (area-weighted) is estimated to be 0.71 mCi $^{90}Sr/km^2$ for a mean precipitation amount of 728 mm (area-weighted), i.e. 3.7 times the fall-out in 1973.

A comparison between the amounts of precipitation found in the rain gauges used by the Danish Meteorological Institute[9] and the amounts collected in our rain bottles at the same locations in 1974 showed a mean ratio of 1.06 $\pm$ 0.02 (1 SE) between the two sampling systems.

Table 4.1.1

Strontium-90 fall-out in Denmark in 1974

Period	Unit	Tylstrup	Studsgård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Virumgård	Abed	Åkirkeby	Ledreborg	Mean*
Jan.-Feb.	pCi/l	0.37	0.40	0.34	0.61	0.26	0.28	0.32	0.41	0.39	0.45	0.32	0.38
	mCi/km^2	0.043	0.063	0.036	0.079	0.037	0.033	0.030	0.041	0.039	0.048	0.028	0.044
Mar.-Apr.	pCi/l	2.59	2.24	2.41	2.29	2.05	2.45	1.98	3.35	1.77	0.35	2.26	2.35
	mCi/km^2	0.042	0.061	0.082	0.063	0.068	0.068	0.051	0.088	0.069	0.072	0.035	0.066
May-June	pCi/l	8.07	3.09	3.31	3.12	(3.77)	6.86	4.67	3.53	2.57	4.78	4.33	4.38
	mCi/km^2	0.326	0.253	0.108	0.271	(0.287)	0.327	0.234	0.148	0.180	0.179	0.240	0.230
July-Aug.	pCi/l	1.34	1.39	1.25	1.53	1.38	0.80	1.95	1.10	1.56	2.22	0.85	1.45
	mCi/km^2	0.156	0.222	0.158	0.301	0.256	0.139	0.175	0.157	0.137	0.202	0.156	0.190
Sep.-Oct.	pCi/l	0.57	0.46	0.42	0.68	0.51	0.55	0.82	0.55	0.63	0.42	0.64	0.56
	mCi/km^2	0.075	0.097	0.070	0.134	0.113	0.073	0.094	0.067	0.082	0.121	0.063	0.093
Nov.-Dec.	pCi/l	0.38	0.41	0.41	0.42	0.44	0.32	0.39	0.33	0.40	0.52	0.37	0.39
	mCi/km^2	0.079	0.113	0.064	0.143	0.117	0.066	0.070	0.048	0.080	0.089	0.058	0.087
1974	pCi/l $\bar{x}$	1.15	0.89	0.83	1.01	0.93	1.00	1.18	0.94	0.95	0.98	1.01	0.98
	mCi/km^2 Σ	0.721	0.809	0.516	0.991	0.858	0.706	0.654	0.546	0.597	0.711	0.580	0.710
mm precipitation Σ		628	914	621	979	920	707	554	677	631	725	677	726

*Ledreborg not included in mean.

Figures in brackets calculated from VAR3[12].

Table 4.1.2

Analysis of variance of ln pCi $^{90}Sr/l$ precipitation in 1974

(from table 4.1.1)

Variation	SSD	f	s^2	v^2	P
Betw. locations	0.520	10	0.052	0.88	-
Betw. months	53.713	5	10.743	181.82	>99.95%
Remainder	2.895	49	0.059		

Table 4.1.3

Analysis of variance of ln mCi $^{90}Sr/km^2$ precipitation in 1974

(from table 4.1.1)

Variation	SSD	f	s^2	v^2	P
Betw. locations	2.416	10	0.242	4.19	> 99.95%
Betw. months	22.080	5	4.416	76.50	> 99.95%
Remainder	2.828	49	0.058		

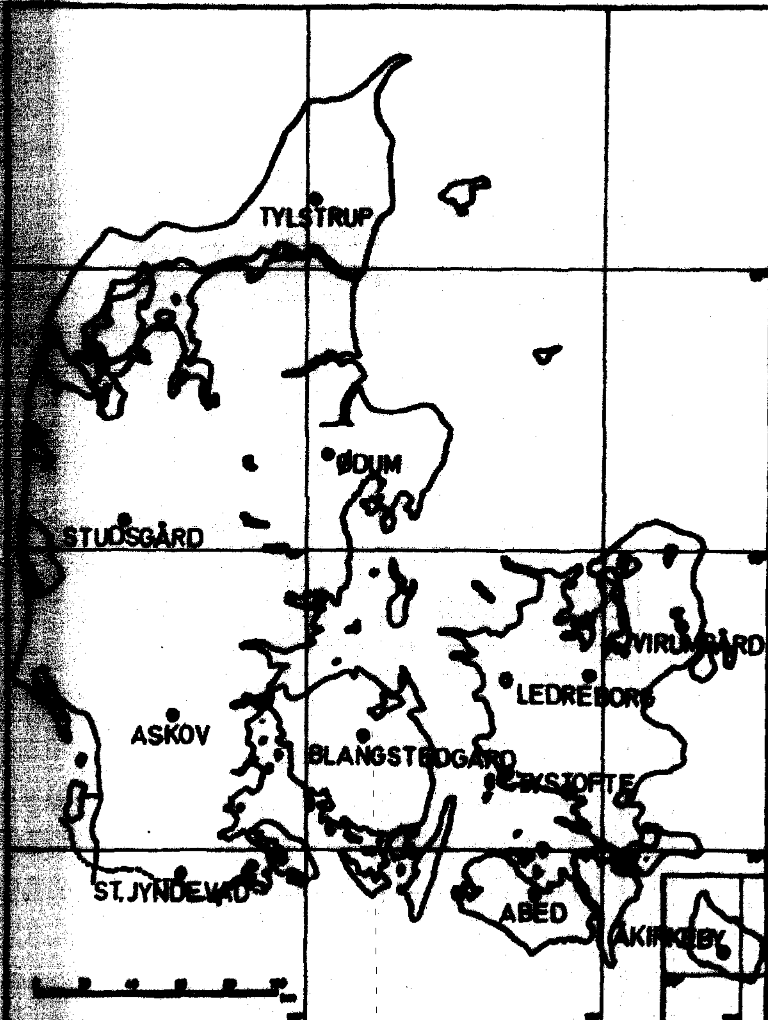

Fig. 4.1.1. State experimental farms in Denmark.

4.2. Strontium-90 and Caesium-137 in Soil

As in previous years, soil was collected with a view to estimating the accumulated fall-out. The samples were collected in September from uncultivated areas all over the country (cf. fig. 4.1.1), down to a depth of 50 cm.

Tables 4.2.1 and 4.2.2 show the ^{90}Sr results. The mean values of the State experimental farms were 56 mCi $^{90}Sr/km^2$.

From precipitation data[1,17], the accumulated fall-out in Denmark in 1974 was calculated to be 53 mCi/km^2, i.e. nearly equal to the level found in table 4.2.1, considering that two low fall-out stations (VIR and ÅKI) are missing in the mean.

The determination of ^{137}Cs is shown in tables 4.2.3 and 4.2.4. The mean values of the State experimental farms were 94 mCi $^{137}Cs/km^2$.

Table 4.2.5 finally shows the $^{137}Cs/^{90}Sr$ ratios in the samples. The mean ratio was 1.7, i.e. lower than observed earlier, but still greater than the theoretical ratio of 1.45[4]. The reason for the lower ratio this year may be due to the increased sampling depth, which essentially includes all the deposited ^{90}Sr.

Table 4.2.1

Strontium-90 in soil collected at the state experimental farms in September 1974
(0-50 cm)

	Tylstrup*	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Abed	Åkirkeby	Mean	SD	SE
mCi ^{90}Sr/km^2	57	68	46	64	70	51	45	78	45$^{\nabla}$	[illegible]	[illegible]	8
pCi ^{90}Sr/kg	73	89	62	83	71	76	56	75	114$^{\nabla}$	[illegible]	[illegible]	[illegible]

*new plot
$^{\nabla}$collected in May (0-30 cm) not included in the mean.

Table 4.2.3

Caesium-137 in soil collected at the state experimental farms in September 1974
(0-50 cm)

	Tylstrup*	Studs-gaard	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Abed	Åkirkeby	Mean	SD	SE
mCi ^{137}Cs/km^2	109	88	98	105	113	77	79	79	87$^{\nabla}$	94	15	5
pCi ^{137}Cs/kg	139	118	132	137	116	115	98	126	206$^{\nabla}$	122	14	5
g K/kg	14.5	7.0	15.5	13.7	7.2	15.3	16.5	13.8	17.5$^{\nabla}$	12.9	3.7	1.3

*New plot.
$^{\nabla}$Collected in May (0-30 cm), not included in the mean.

Table 4.2.2

Strontium-90 in soil collected from the surroundings of Roskilde in September 1974
(0-50 cm)

	Bolund	Ledreborg (Roskilde Fælled)	Skydebanen	Mean	SD	SE
mCi ^{90}Sr/km^2	63	51	54	56	6	4
pCi ^{90}Sr/kg	90	68	74	77	11	7

Table 4.2.4

Caesium-137 in soil collected from the surroundings of Roskilde in September 1974 (0-50 cm)

	Bolund	Ledreborg (Roskilde Fælled)	Skydebanen	Mean	SD	SE
mCi $^{137}Cs/km^2$	79	84	93	85	7	4
pCi $^{137}Cs/kg$	135	113	127	125	11	6
g K/kg	16.5	18.2	18.[illegible]	17.7	1	0.6

Table 4.2.5

The ratio $^{137}Cs/^{90}Sr$ in soil (0-50 cm) from the state experimental farms, 1974 (from tables 4.2.1 and 4.2.3)

lstrup	Studsgård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Abed	Åkirkeby	Mean	SD	SE
1.91	1.29	2.13	1.64	1.6[illegible]	1.51	1.76	1.65	1.82	1.70	0.24	0.08

Table 4.2.6

The ratio $^{137}Cs/^{90}Sr$ in soil (0-50 cm) collected from the surroundings of Roskilde, 1974 (from tables 4.2.2 and 4.2.4)

Bolund	Ledreborg (Roskilde Fælled)	Skydebanen	Mean	SD	SE
1.25	1.65	1.72	1.54	0.25	0.15

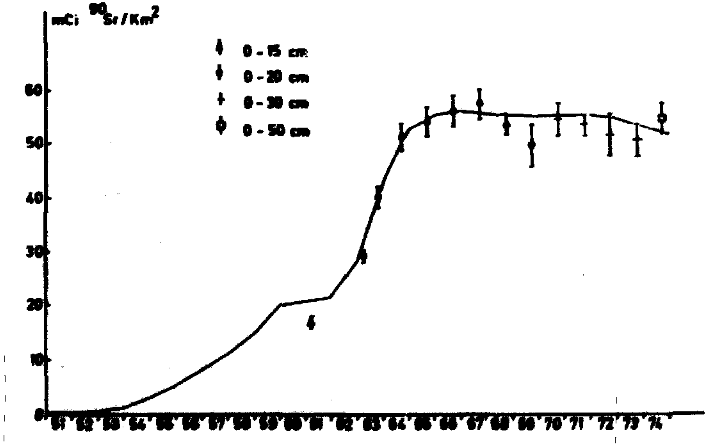

Fig. 4.2. A comparison between measured levels in soil collected in various depths ($\pm$ 1 S.E.) and calculated (the curve) assuming an effective half-life of 27.7 y.

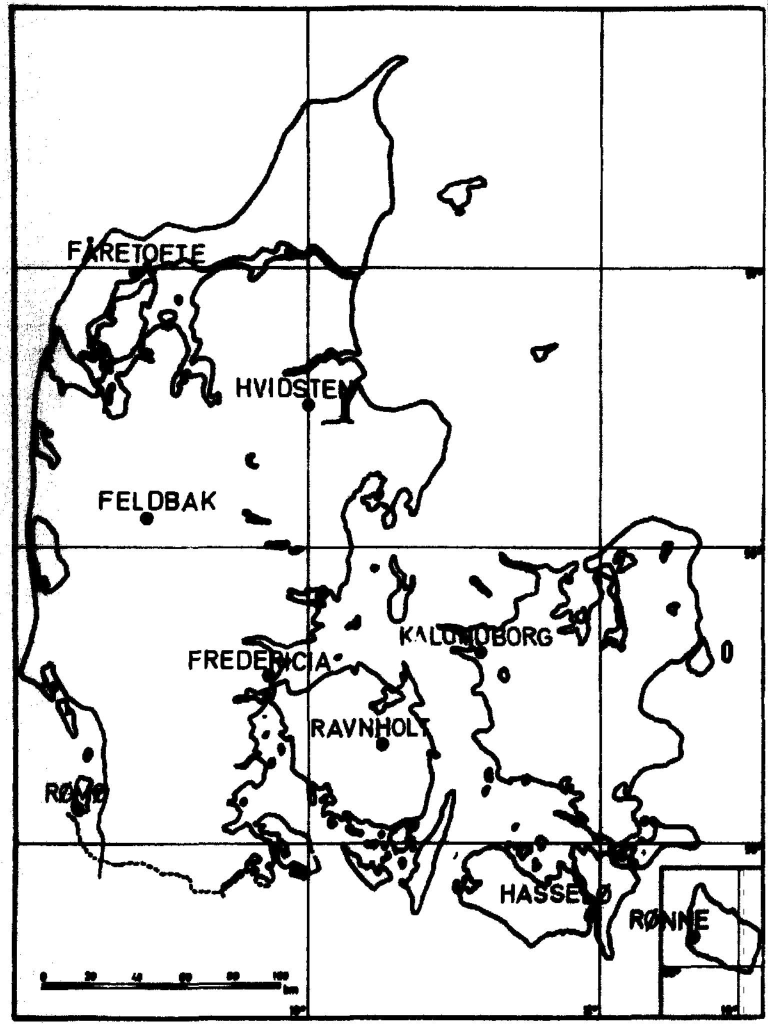

Fig. 4.3.1. Ground-water sampling locations in Denmark.

4.3. Strontium-90 in Ground Water

As in previous years, ground water was collected in March from the nine locations selected by the Geological Survey of Denmark.

Figure 4.3.1 shows the sample locations and table 4.3.1 the results of the ^{90}Sr analyses (cf. also 5.8.4).

The median level of ^{90}Sr in 1974 was equal to that found in 1973. Figure 4.3.2 shows the median levels in Danish ground water since 1961.

Table 4.3.1

Strontium-90 in ground water collected in March 1974

	pCi ^{90}Sr/l	g Ca/l	mg Sr/g Ca
Hvidsten	0.002	0.055	2.0
Feldbak	1.65	0.025	0.1
Rømø	0.007 A	0.034	2.5
Rønne	0.002 B	0.021	1.0
Hasselø	0.006 A	0.126	2.0
Fåretofte	0.003 B	0.143	1.0
Kalundborg	0.034	0.097	0.5
Ravnholt	0.013 A	0.138	0.5
Fredericia	0.006	0.072	1.6
Mean	0.191	0.079	1.2
Median	0.006	0.072	1.0
Ion-exchanged water 0.011 pCi ^{90}Sr/l			

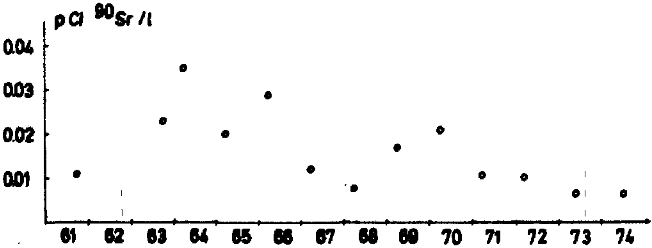

Fig. 4.3.2. Median ^{90}Sr levels in Danish waters, 1961-74.

Due to the high levels of ^{90}Sr in ground water from Feldbak (cf. fig. 4.3.3), we repeated the sampling in October 1974. The level in this sample was 1.35 pCi ^{90}Sr/l, i.e. a little lower than in the March sample.

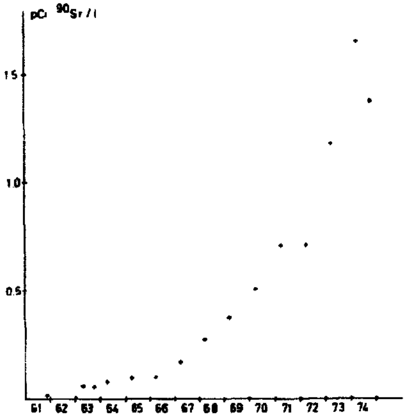

Fig. 4.3.3. Strontium-90 in ground water at Feldbak 1961-74.

5. RADIOSTRONTIUM AND RADIOCAESIUM IN DANISH FOOD IN 1974

5.1. Strontium-90 and Caesium-137 in Dried Milk from the Entire Country

As in the previous years, monthly samples of dried milk were collected from seven locations in Denmark (cf. fig. 5.1.1) and analysed for ^{90}Sr and ^{137}Cs.

Table 5.1.1 shows the results of the ^{90}Sr determinations and table 5.1.2 the analysis of variance of the results. As in 1972 and 1973, but contrary to previous years, the variation between months was significant for S.U.; the levels in November were higher than the mean levels. The S.U. mean level in 1974 was 4.5 pCi ^{90}Sr/g Ca or approx. equal to the 1973 mean.

Table 5.1.1

Strontium-90 (pCi/g Ca) in Danish dried milk in 1974

Month	Hjørring	Arhus	Videbæk	Abenrå	Odense	Ringsted	Lolland-Falster Møn	Mean
Jan.	5.6	3.6	[illegible]	5.3	3.4	2.9	2.9	4.2
Feb.	4.6	4.2	5.8	5.4	3.4	3.2	2.1	4.1
Mar.	4.4	3.7	5.6	5.6	4.4	3.6	2.7	4.3
Apr.	4.1	5.1	6.2	6.6	3.9	2.2	2.3	4.4
May	5.0	3.9	6.0	4.7	3.3	3.0±0.7*	2.3	4.2
June	4.8	6.0	5.4	5.4	2.5	3.4	2.1	4.2
July	5.4	4.7	6.2	6.6	4.2	3.4	2.7	4.7
Aug.	4.9	5.2	6.0	6.0	3.6	3.2	2.4	4.5
Sep.	3.0	5.4	6.1	5.9	3.3	2.3	2.5	4.2
Oct.	6.4	5.3	4.7	6.0	4.2	3.9	3.2	4.8
Nov.	6.0	6.3	7.5	9.2	4.1	3.9	3.7	5.8
Dec.	5.3	4.4	6.8	(6.4)	4.0	3.7	3.0	4.8
Mean	5.0	4.8	6.1	6.1	3.8	3.3	2.7	4.5

*Double determination

As 1 litre of milk contains 1.2 g Ca, the mean ^{90}Sr content in Danish milk produced in 1974 was 5.4 pCi/l.

Table 5.1.2

Analysis of variance of ln pCi ^{90}Sr/g Ca in dried milk in 1974 (from table 5.1.1)

Variation	SSD	f	s^2	v^2	P
Betw. locations	7.084	6	1.181	57.57	>99.95%
Betw. months	0.802	11	0.073	3.56	>99.9%
Remainder	1.333	65	0.021		

As previously, milk from eastern Denmark showed significantly lower levels than that from Jutland.

Table 5.1.3 shows the results of the ^{137}Cs determinations and table 5.1.4 the analysis of variance of the results. The M.U. mean level in 1974 was 4.4 pCi ^{137}Cs/g K or 22% higher than the 1973 level.

Figures 5.1.2 and 5.1.3 show the quarterly S.U. and M.U. values since October-December 1959 (cf. also Appendix C).

Table 5.1.3.

Caesium-137 pCi/g K in Danish dried milk in 1974

Month	Hjørring	Arhus	Videbæk	Abenrå	Odense	Kingsted	Lolland-Falster Møn	Mean
Jan.	3.4	2.6	3.7	2.3 A	1.9	2.2	1.3 A	2.5
Feb.	1.9 B	3.1	2.6	3.4	2.1	0.6 B	2.9	2.4
Mar.	5.4	5.2	5.1	4.1	3.1	1.8 A	0.4 B	3.6
Apr.	4.5	3.6	4.6	4.6	2.2 A	1.8	1.7	3.3
May	3.3 A	4.4	4.1	3.3	3.9	2.6±0.6*	2.0 A	3.4
June	7.1	7.2	8.9	9.0	3.5	4.1	3.4	6.2
July	11.5	6.2	7.7	9.0	6.8	2.9 A	3.7	6.8
Aug.	9.4	5.9	9.3	9.3	5.4	4.6	2.8	6.7
Sep.	8.2	6.0	7.8	8.6	4.2	2.7	2.5	5.7
Oct.	6.6	4.1	6.4	7.1	3.5	2.3	2.7	4.7
Nov.	5.0	4.0	6.4	6.8	1.1 B	2.6	3.3	4.2
Dec.	4.9	3.5	6.6	(5.0)	2.5	2.2 A	1.7 A	3.8
Mean	5.9	4.6	6.1	6.0	3.4	2.5	2.4	4.4

As 1 litre of milk contains approx. 1.66 g K, the mean ^{137}Cs content in Danish milk in 1974 was estimated at 7.30 pCi/l.

*Double determination

Table 5.1.4

Analysis of variance of in pCi ^{137}Cs/g K in Danish dried milk 1974
(from table 5.1.3)

Variation	SSD	f	s^2	v^2	P
Betw. locations	13.434	6	2.239	19.19	>99.95%
Betw. months	10.641	11	0.967	8.29	>99.95%
Remainder	7.584	65	0.117	-	-

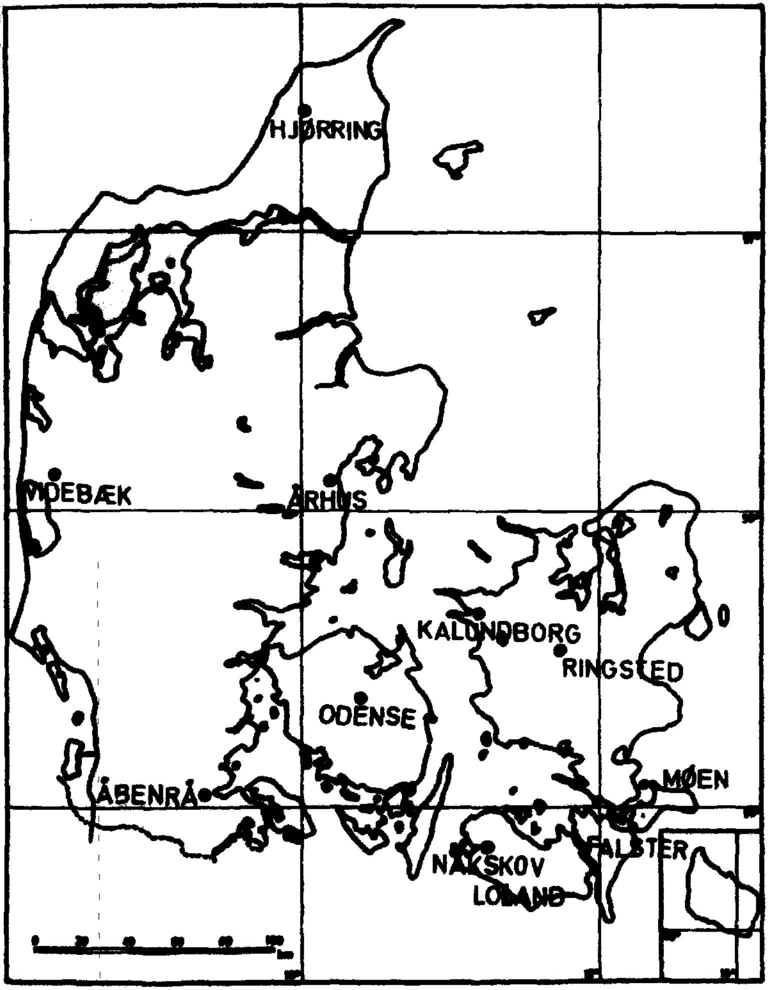

Fig. 5.1.1. Dried-milk factories in Denmark.

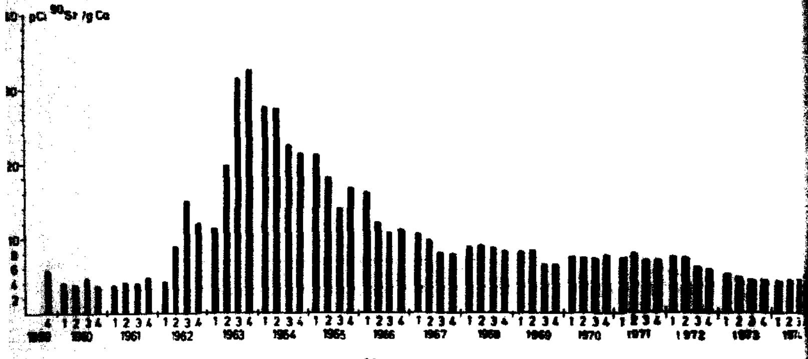

Fig. 5.1.2. Quarterly ^{90}Sr levels in dried milk, 1959-74.

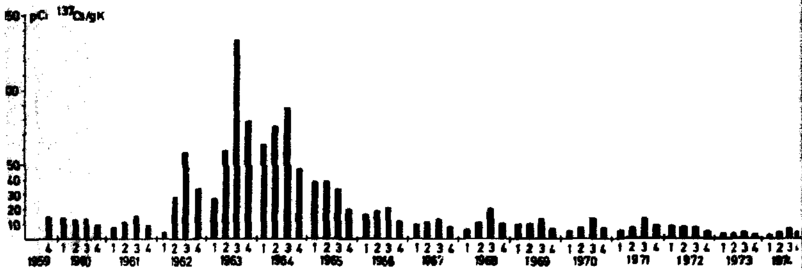

Fig. 5.1.3. Quarterly ^{137}Cs levels in dried milk, 1959-74.

5.2. Strontium-90 and Caesium-137 in Fresh Milk from the Entire Country

The samples of fresh milk were collected in the eight zones and in Copenhagen (cf. fig. 5.2.1) in connection with the total-diet collection (cf. 5.7).

Table 5.2.1 shows the results of the determinations of radiostrontium and ^{137}Cs in consumer milk.

The production-weighted means for ^{90}Sr and ^{137}Cs in Danish consumer milk in 1974 collected in June and December were 4.2 S.U. (~5 pCi ^{90}Sr/l) and 3.8 M.U. or 6.3 pCi ^{137}Cs/l respectively.

As observed previously (except in 1973), the fresh milk showed lower levels than the corresponding dried milk.

Table 5.2.1

Strontium-90 and Caesium-137 in fresh milk in 1974

Zone	June			December		
	pCi ^{90}Sr/g Ca	pCi ^{137}Cs/g K	pCi ^{137}Cs/l	pCi ^{90}Sr/g Ca	pCi ^{137}Cs/g K	pCi ^{137}Cs/l
I: N-Jutland	3.6	3.9	6.4	4.6	3.9	5.9
II: E-Jutland	4.1	4.2	7.2	4.2	3.8	6.5
III: W-Jutland	5.2	5.8	9.2	5.2	4.5	7.7
IV: S-Jutland	5.1	4.8	8.2	3.9	1.5	2.1
V: Funen	3.0	1.6 A	2.6	3.7	2.0	3.2
VI: Zealand	2.6 A	3.0	4.7	3.6	2.3	3.6
VII: Lolland-Falster	2.6 A	1.1 B	1.6	3.9	2.7	4.2
VIII: Bornholm	3.3	2.0 A	3.4	3.5	2.0	4.1
Mean	3.7	3.3	5.5	4.0	2.8	4.5
Copenhagen	3.0	1.7	2.7	3.5	2.1	3.0
Population-weighted mean	3.6	3.2	5.6	4.0	2.9	4.6
Production-weighted mean	4.1	4.2	7.0	4.3	3.4	5.5

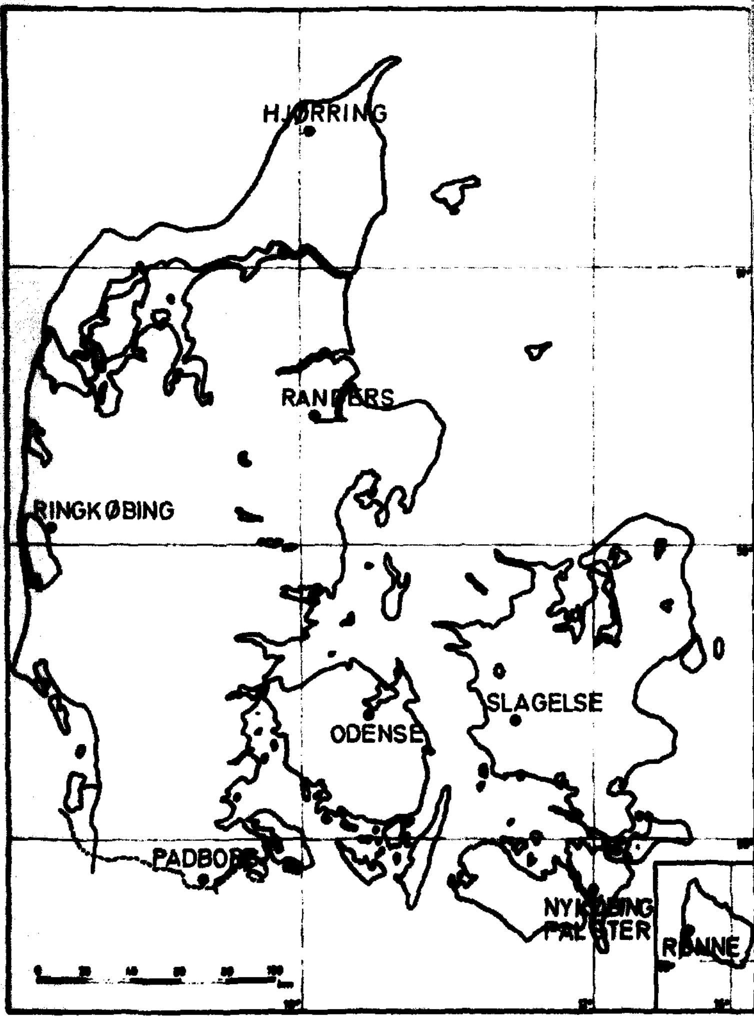

Fig. 5.2.1. Sample locations for fresh milk, bread and total diet in 1973

5.3. Strontium-90 and Caesium-137 in Grain from the Entire Country

As in previous years, grain samples were obtained from ten State experimental farms (cf. fig. 4.1.1). Virumgård was replaced by Ledreborg in 1969. Strontium-90 was determined as previously (Risø Report No. 63[1]), and ^{137}Cs was measured on ashed samples by Y-spectrometry on a Ge-detector.

Table 5.3.1

Strontium-90 in Danish grain in 1974

	Rye		Barley		Wheat		Oats	
	pCi ^{90}Sr/kg	S.U.	pCi ^{90}Sr/kg	S.U.	pCi ^{90}Sr/kg	S.U.	pCi ^{90}Sr/kg	S.U.
ylstrup	36	107	42	109	s: 20	s: 42	74	99
udsgård	42	144	51	92	w: 62 s: 58	w: 130 s: 119	46	45
dum	-	-	74	54	w: 14 s: 19	w: 52 s: 45	26	29
skov	37	97	39	85	w: 37 s: 63	w: 104 s: 134	58	78
. Jyndevad	45	128	52	97	w: 39	w: 163	61	80
langstedgård	-	-	19	35	w: 34	w: 131	22	24
ystofte	26	77	31	59	s: 38 w: 23	s: 74 w: 80	49	55
edreborg	15	46	11	27	w: 23 s: 27	w: 49 s: 71	26	30
bed	-	-	17	32	w: 14 s: 17	w: 10 s: 36	16	17
kirkeby	24	73	18	40	w: 16 s: 26	w: 53 s: 59	26	37
Mean	32	96	30	62	31	89	40	48

w: winter variety, s: spring variety.

Table 5.3.2

Analysis of variance of ln S.U. in grain in 1974
(from table 5.3.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	1.972	3	0.657	5.31	>99%
Betw. locations	9.282	9	1.031	8.33	>99.95%
Spec. x loc.	2.971	24	0.124	0.972	-
Remainder	0.891	7	0.127		

Table 5.3.1 shows the measurements of ^{90}Sr in grain in 1974. According to Appendix B, approx. 2/3 of all rye in Denmark is grown in Jutland and 1/3 in the eastern part of the country. As regards wheat, 4/5 is produced in eastern Denmark and 1/5 in Jutland. In the calculation of the means in tables 5.3.1 and 5.3.4, Jutland is represented by four rye figures

Table [illegible]

[illegible] of variance of ln pCi [illegible] [illegible] grain in [illegible]
(from table [illegible])

Variation	SSD	f	s^2	v^2	P
Betw. species	0.648	3	0.216	[illegible].79	-
Betw. locations	[illegible]	9	[illegible]	[illegible]	>99.95%
Species x loc.	1.[illegible]	24	[illegible]	1.1[illegible]	-
Remainder	0.[illegible]	7	0.066		

Table 5.3.4

Caesium-137 in Danish grain in 1974

	Rye		Barley		Wheat		Oats	
	pCi ^{137}Cs/kg	M.U.	pCi ^{137}Cs/kg	M.U.	pCi ^{137}Cs/kg	M.U.	pCi ^{137}Cs/kg	M.U.
Tylstrup	29	6.1	24	5.3	s: 39	s: 9.1	42	8.[illegible]
Studsgård	77	15.7	43	8.1	w: 40 s: 41	w: 11.8 s: 11.2	60	12.[illegible]
Ødum	-	-	24	5.6	w: 15 s: 26	w: 3.8 s: 5.2	19	4.[illegible]
Askov	66	13.4	38	8.4	w: 35 s: 43	w: 8.6 s: 9.0	45	9.[illegible]
St. Jyndevad	86	15.8	36	7.4	w: 38	w: 8.7	48	10.[illegible]
Blangstedgård	-	-	20	4.7	w: 24	w: 6.0	21	5.[illegible]
Tystofte	40	8.5	30	6.2	w: 24 s: 25	w: 5.1 s: 5.4	33	9.[illegible]
Ledreborg	24	5.2	20	6.4	w: 35 s: 18	w: 7.4 s: 4.8	49	12.4
Abed	-	-	27	5.9	w: 31 s: 25	w: 6.6 s: 5.5	30	8.[illegible]
Åkirkeby	37	8.3	32	7.5	w: 28 s: 32	w: 7.0 s: 7.7	30	6.[illegible]
Mean	51	10.4	29	6.6	31	7.2	38	8.6

w: winter variety, s: spring variety.

Table 5.3.5

Analysis of variance of ln pCi ^{137}Cs/g K in grain in 1974
(from table 5.3.4)

Variation	SSD	f	s^2	v^2	P
Betw. species	0.535	3	0.178	3.40	>95%
Betw. locations	2.705	9	0.301	5.74	>99.95%
Species x loc.	1.257	24	0.052	2.11	-
Remainder	0.173	7	0.025		

Table 5.3.6

Analysis of variance of ln pCi ^{137}Cs/kg in grain in 1974
(from table 5.3.4)

Variation	SSD	f	s^2	v^2	P
Betw. species	0.749	3	0.250	4.99	>99%
Betw. locations	3.159	9	0.351	7.02	>99.95%
Species x loc.	1.202	24	0.050	0.91	-
Remainder	0.385	7	0.055		

and eight wheat figures, while eastern Denmark contributes nine wheat figures and three rye figures. Thus the means in tables 5.3.1 - 5.3.4 for wheat are higher than the production-weighted means for the country, while the rye means are perhaps too low. Table 5.3.2 gives the analysis of variance of the S.U. figures and table 5.3.3 that of the pCi ^{90}Sr/kg grain figures.

Table 5.3.2 shows that the variations in S.U. between species and locations were significant. Rye showed the highest S.U. levels and oats the lowest. The pCi ^{90}Sr/kg figures did not show any significant difference between species.

As in previous years, the variation with location was highly significant; the mean pCi ^{90}Sr/kg level for grain from Jutland was 1.8 times that in eastern Denmark.

Table 5.3.4 shows the measurements of ^{137}Cs in grain in 1974, table 5.3.5 the analysis of variance of the M.U. figures and table 5.3.6 the analysis of variance of the pCi ^{137}Cs/kg grain figures. The ^{137}Cs levels in grain from 1974 were 1.5 times the levels in 1972. The ratio between fall-out in May-August in 1974 and 1972 was 1.65. We did not use 1973 for our comparison because the levels in this year were so low that the accuracy of the determinations prohibited a comparison (cf. Risø Report No. 305[1]).

Comparing the S.U. levels in grain from the harvest of 1974 with the levels from 1973[1], we find that the 1974 figures are 1.40 times the 1973 levels.

In Appendix C is shown a comparison between observed and predicted ^{90}Sr and ^{137}Cs levels in 1974.

Table 5.3.7 shows the stable strontium content in grain in relation to the calcium content, and table 5.3.8 is an analysis of variance of the figures. As previously[1], wheat contained more stable strontium per g Ca than the other species, and the stations in Jutland generally showed higher figures than the eastern locations.

Table 5.3.7

Stabile strontium in grain (mg Sr/g Ca) collected in 1974

	Rye	Barley	Wheat		Oats
	w	s	w	s	s
Tylstrup	1.5	2.7		2.2	2.2
Studsgård	5.6	3.7	4.6	3.8	1.9
Ødum		2.3	2.8	2.3	1.9
Askov	2.8	3.3	3.7	4.7	3.2
St. Jyndevad	3.7	2.6	4.7		2.6
Blangstedgård		1.6	2.0		1.1
Tystofte	3.2	3.7	5.9	3.9	3.5
Ledreborg	1.9	3.4	2.6	3.4	1.0
Abed		3.0	4.8	3.5	1.9
Åkirkeby	0.3	2.2	2.8	2.2	1.3
Mean	2.7	2.8	3.5		2.0
Median	2.8	2.8	3.5		1.9

Table 5.3.8

Analysis of variance of ln mg Sr/g Ca in grain in 1974
(from table 5.3.7)

Variation	SSD	f	s^2	v^2	P
Betw. species	2.517	3	0.839	5.36	>99%
Betw. locations	5.367	9	0.596	3.81	>99.5%
Species x loc.	3.760	24	0.157	4.04	>95%
Remainder	0.271	7	0.039		

5.4. Strontium-90 and Caesium-137 in Bread from the Entire Country

In 1974, samples of white bread (75% extraction) and dark rye bread (100% extraction) were collected all over the country in June, and ^{90}Sr and ^{137}Cs were determined. The ^{137}Cs determinations were carried out on the ash by Ge γ-spectroscopy.

Tables 5.4.1 and 5.4.2 show the results. It is assumed that 1 kg flour yields approx. 1.35 kg bread[11] and that wheat flour of 75% extraction contains 20% of the ^{90}Sr and 50% of the ^{137}Cs found in wheat grain[1], while rye flour is 100% extraction. Hence we can compare the 1974 bread levels with the 1973 grain levels (cf. table 5.4.3).

Table 5.4.3 shows that the ^{90}Sr and ^{137}Cs levels in bread were higher than those in grain according to the above-mentioned model.

Table 5.4.1

Strontium-90 in Danish bread in June 1974

Zone		White bread		Rye bread	
		pCi/kg	S.U.	pCi/kg	S.U.
I:	N-Jutland	4.4	2.6	24	13
II:	E-Jutland	4.7	2.2	35	32
III:	W-Jutland	4.1	2.0	24	8
IV:	S-Jutland	4.6	2.5	29	27
V:	Funen	4.9	2.4	17	7
VI:	Zealand	5.0	2.4	16	4
VII:	Lolland-Falster	5.6	2.7	24	8
VIII:	Bornholm	6.0	3.8	15	5
Mean		4.9	2.6	23	13
Copenhagen		5.7	2.4	18	6
Population-weighted mean		5.0	2.4	23	12

Table 5.4.2

Caesium-137 in Danish bread in June 1974

Zone		White bread		Rye bread	
		pCi/kg	M.U.	pCi/kg	M.U.
I:	N. Jutland	5.7 B	3.7 B	11.0 A	2.8 A
II:	E. Jutland	6.6 B	4.2 B	27.0	7.0
III:	W. Jutland	1.6 B	1.0 B	12.4	3.9
IV:	S. Jutland	7.0 A	4.9 A	19.5	5.6
V:	Funen	3.2 B	2.0 B	13.2 A	4.9 A
VI:	Zealand	4.7 B	3.3 B	0	0
VII:	Lolland-Falster	4.7 B	2.7 B	4.1 B	1.2 B
VIII:	Bornholm	9.6 A	6.2 A	9.5 A	2.3 A
Mean		5.4	3.5	12.1	3.5
Copenhagen		2.0 B	1.3 B	4.4 B	1.4 B
Population-weighted mean		4.0	2.6	10.8	3.1

Table 5.4.3

A comparison ^{90}Sr and ^{137}Cs levels in bread and grain in 1974

Nuclide	Species	Bread activity in June 1974 calculated as grain in pCi/kg (cf. text)	Activity in grain from harvest 19[illegible] [1)] pCi/kg	"Bread"/grain ratio
^{90}Sr	Wheat	[illegible]	[illegible]	1.[illegible]
	Rye	[illegible]	[illegible]	1.[illegible]
^{137}Cs	Wheat	[illegible]	[illegible]	1.4
	Rye	[illegible]	[illegible]	1.3

5.5. Strontium-90 and Caesium-137 in Potatoes from the Entire Country

The samples of potatoes were collected in September from ten of the State experimental farms (cf. fig. 4.1.1) and analysed for ^{90}Sr and ^{137}Cs (γ-spectroscopy of bulked samples of the ash).

Table 5.5.1

Strontium-90 and Caesium-137 in Danish potatoes in 1974

	pCi ^{90}Sr/kg	S.U.	pCi ^{137}Cs/kg	M.U.
Tylstrup	3.0	91		
Studsgård	2.9	86		
Ødum	2.3	48	9.2	2.2
Askov	5.3±0.2	147±4		
St. Jyndevad	4.9±0.0	144±3		
Blangstedgård	2.1±0.3	29±4		
Tystofte	2.6±0.1	40±1		
Ledreborg	2.2±0.3	42±6	3.4	0.9
Åbed	2.4	32		
Rønne	4.7±0.2	144±5		
Mean	3.2	80	6.3	1.6

Table 5.5.1 shows the ^{90}Sr and ^{137}Cs contents in potatoes. The mean contents for the country were 3.2 pCi ^{90}Sr/kg or 80 S.U. and 6.3 pCi ^{137}Cs/kg or 1.6 M.U. The levels were not significantly different from those of 1973.

The mean of the $^{137}Cs/^{90}Sr$ ratios (pCi/kg figures) was 2.0 (in 1973: 1.4, in 1972: 1.7, in 1971: 3.1, in 1970: 3.8, in 1969: 1.8, in 1968: 2.6, in 1967: 2.1, in 1966: 2.6, in 1965: 6, and in 1964: 9).

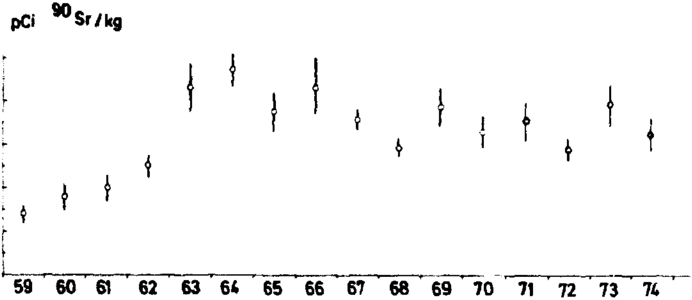

Fig. 5.5.1. Strontium-90 in Danish potatoes, 1959-74 (1 S.E. indicated).

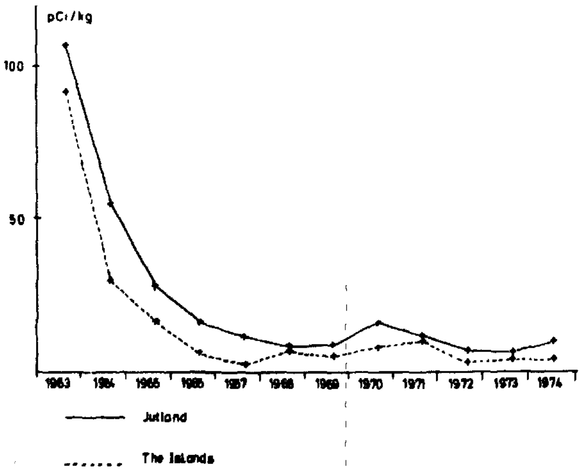

Fig. 5.5.2. Caesium-137 in potatoes from Jutland and the Islands, 1963-74.

5.6. Strontium-90 and Caesium-137 in Vegetables and Fruits from the Entire Country

In 1974, as in previous years, vegetables and fruits were collected in September and December from eight larger provincial towns, one in each of the eight zones, and from Copenhagen.

Carrots and onions were collected in September, cabbages and apples in December.

The Y-measurements were performed on bulked ash samples representing the entire country (cf. table 5.6.4). Tables 5.6.1 - 5.6.3 show the results and the analysis of variance of the ^{90}Sr determinations.

The variations between species were highly significant. The highest ^{90}Sr levels (pCi/kg) were found in onion and carrot, the lowest in apple. The variation between locations was not significant.

Table 5.6.1

Strontium-90 in vegetables and fruits in 1974

Zone	Cabbage		Carrot		Onion		Apple	
	pCi/kg	[illegible]	pCi/kg	[illegible]	pCi/kg	[illegible]	pCi/kg	[illegible]
I: N-Jutland	[illegible]	[illegible]	6.7	[illegible]	[illegible]	44	3.4	[illegible]
II: E-Jutland	[illegible]	40	[illegible]	[illegible]	46.1	91	[illegible]	39
III: W-Jutland	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
IV: S-Jutland	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51	[illegible]	[illegible]
V: Funen	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VI: Zealand	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VII: Lolland-Falster	[illegible]	[illegible]	[illegible]	28	[illegible]	[illegible]	[illegible]	43
VIII: Bornholm	10.7	[illegible]	6.8	[illegible]	20.6	42	[illegible]	[illegible]
Mean	11.3	[illegible]	[illegible]	31	21.0	48	2.4	35
Copenhagen	7.9	15	12.0	38	18.7	41	4.3	60
Population-weighted mean	10.2	28	11.4	38	21.2	46	3.0	42

Table 5.6.2

Analysis of variance of ln pCi ^{90}Sr/kg in vegetables and fruits in 1974 (from table 5.6.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	19.774	3	6.591	27.94	>99.95%
Betw. locations	1.396	8	0.174	0.74	-
Remainder	5.662	24	0.236		

Table 5.6.3

Analysis of variance of ln S.U. in vegetables and fruits in 1974
(from table 5.6.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	1.894	3	0.631	2.70	-
Betw. locations	1.745	8	0.218	0.93	-
Remainder	5.606	24	0.234		

Table 5.6.4

Caesium-137 in vegetables and fruits in 1974

	Cabbage	Carrot	Onion	Apple	Pea	Gooseberry
pCi/kg	1.1	1.1	0.7 B	4.7	*3.7 B	Δ3.6 A
pCi/g K	0.5	0.5	0.4 B	2.8	*0.7 B	Δ1.6 A

*Only Copenhagen

ΔOnly Vejle, Odense and Copenhagen.

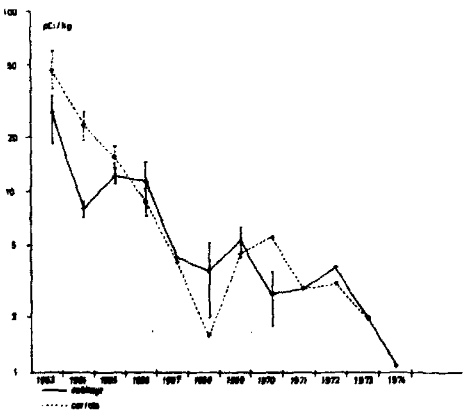

Fig. 5.6.1. Strontium-90 in Danish cabbage and carrots 1961-74 (1 S.E. indicated).

Figure 5.6.1 shows the country-wide mean pCi $^{90}Sr/g$ Ca levels in cabbage (white and red) and in carrots collected since 1961. The cabbage levels have since 1966 varied around 20 pCi $^{90}Sr/g$ Ca and the carrot levels have been only 30 pCi $^{90}Sr/g$ Ca, (cf. discussion in Risø Report No. 291[1]).

The ^{90}Sr levels in cabbage and carrots depend primarily on the ^{90}Sr activity in the soil; during the last years approx. 95% of the ^{90}Sr came from the accumulated ^{90}Sr in the soil. The relatively constant levels since 1966 are in accordance with the almost constant soil levels (cf. 4.2) and support the statement in Appendix C that the availability of the ^{90}Sr in the soil for root uptake does not decrease so rapidly as suspected in 1971.

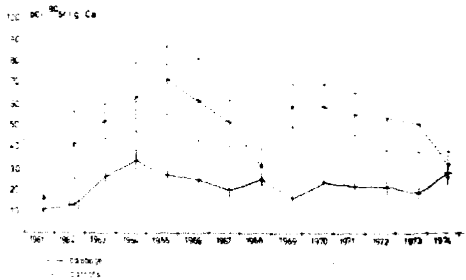

Fig. 5.6.2. Caesium-137 in Danish cabbage and carrots 1963-74. (1 S.E. indicated, when more than one determination was carried out).

Figure 5.6.2 shows the corresponding curve for ^{137}Cs in cabbage and carrots, (notice that the ordinate is logarithmic). It is evident that ^{137}Cs in vegetables, unlike ^{90}Sr, depends strongly on the fall-out rate. It also appears that the levels in cabbage and carrots are similar, implying, that the ^{137}Cs is translocated in carrots from the parts above the soil to the roots. The ^{137}Cs levels in vegetables are now so low that a meaningful interpretation of the results is difficult. It is thus surprising that the 1974 levels in cabbage and carrots are apparently lower than the 1973 levels. However, the difference is hardly real because the analytical errors of the 1974 determinations are large.

Table 5.6.5 shows a calculation of the mean contents of ^{90}Sr and ^{137}Cs in Danish vegetables collected in 1974, (^{90}Sr in peas was taken to be the same as the 1973 figures). The levels are the population-weighted means calculated in tables 5.6.1 - 5.6.4.

Table 5.6.[illegible]

Calculated ^{90}Sr and ^{137}Cs mean levels in vegetables in 1974

Daily intake in g	[illegible]	pCi ^{90}Sr per kg	[illegible]	pCi ^{137}Cs per kg	[illegible]
[illegible]	Leafy vegetables (cabbage)	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Root vegetables (carrots, [illegible])	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Peas	([illegible])	([illegible])	[illegible]	[illegible]
[illegible]	Vegetable total	[illegible]	[illegible]	[illegible]	[illegible]

The ^{90}Sr levels in peas are those found in [illegible].

The 1974 levels in Danish fruit were calculated from apples and the mean levels in Danish fruit were thus 3.0 pCi ^{90}Sr/kg and 4.7 pCi ^{137}Cs/kg.

5.7. Strontium-90 and Caesium-137 in Total Diet from the Entire Country

In 1974 total-food samples representing an average Danish diet according to E. Hoff-Jørgensen (cf. Appendix B in Risø Report No. 63[1]) were collected from eight towns each representing one of the eight zones (cf. fig. 5.2.1) and from Copenhagen. The sampling took place as previously in June and December.

Table 5.7.1

Strontium-90 and Caesium-137 in Danish total diet collected in June 1974

Zone	pCi ^{90}Sr/g Ca	pCi ^{90}Sr/day	g Ca/day	pCi ^{137}Cs/g K	pCi ^{137}Cs/day
I: N. Jutland	7.[illegible]±0.[illegible]	11.9±0.5	1.56±0.01	6.0	24
II: E. Jutland	13.6±0.[illegible]	20.7±0.[illegible]	1.5[illegible]±0.02	2.[illegible]	12
III: W. Jutland	8.3±0.4	13.8±0.7	1.66±0.01	5.3±0.2	23±[illegible]
IV: S. Jutland	11.4±0.[illegible]	18.7±0.0	1.65±0.00	3.8	15
V: Funen	4.7±0.4	9.7±0.9	1.93±0.01	2.4 A	10 A
VI: Zealand	5.1±0.5	9.8±1.1	1.91±0.00	2.1 A	9 A
VII: Lolland-Falster	5.8±0.6	9.5±1.0	1.64±0.01	3.3	13
VIII: Bornholm	5.8±0.6	9.4±1.1	1.54±0.02	2.9	12
Mean	7.8	12.8	1.67	3.6	15
Copenhagen	4.7±0.2	8.8±0.5	1.88±0.01	2.3	10
Population-weighted mean	7.4	12.5	1.74	3.2	14
Relative error due to analysis	8%	9%	1%		

Table 5.7.2

Strontium-90 and Caesium-137 in Danish total diet collected in December 1974

Zone		pCi ^{90}Sr/g Ca	pCi ^{90}Sr/day	g Ca/day	pCi ^{137}Cs/g K	pCi ^{137}Cs/day
I:	N. Jutland	7.2±0.6	11.2±1.1	1.60±0.00	4.4	17
II.	E. Jutland	7.9±0.9	12.9±1.4	1.62±0.01	6.7	23
III:	W. Jutland	8.1±0.7	13.2±1.2	1.63±0.00	7.6	27
IV:	S. Jutland	7.6±0.9	11.7±1.7	1.55±0.03	7.1	26
V:	Funen	6.9±0.1	11.6±0.2	1.70±0.00	2.4	5
VI:	Zealand	6.3±0.8	10.9±1.4	1.73±0.01	3.7	13
VII:	Lolland-Falster	5.6±0.4	10.1±0.6	1.81±0.01	5.5	20
VIII:	Bornholm	6.5±0.5	10.5±0.8	1.62±0.00	4.2	15
Mean		7.0	11.5	1.65	5.2	19
Copenhagen		6.4±0.8	10.6±1.4	1.66±0.03	9.0	34
Population-weighted mean		7.0	11.6	1.65	6.4	23
Relative error due to analysis		14%	14%	1%		

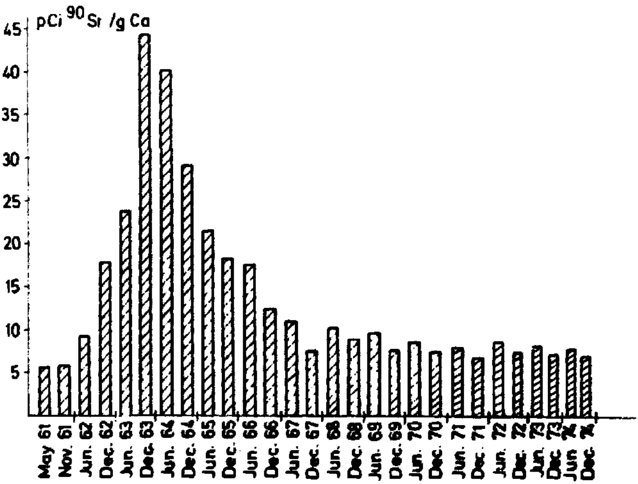

Fig. 5.7.1. pCi ^{90}Sr/g Ca in Danish total diet, 1963-74.

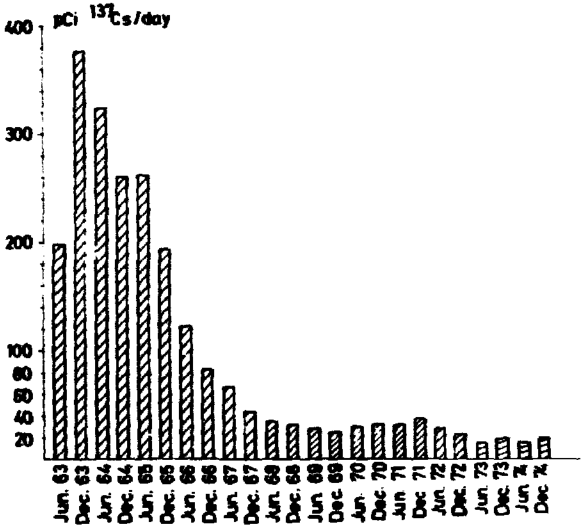

Fig. 5.7.2. pCi ^{137}Cs/day in Danish total diet, 1963-74.

Tables 5.7.1 and 5.7.2 show the results. As in previous years, the variation between locations was significant. The S.U. levels in the total diet were approx. 50% higher in Jutland than in eastern Denmark.

Figure 5.7.1 shows the zone mean levels (not population-weighted) of

Table 5.7.3

Stabile strontium in total diet in 1974

(mg Sr/g Ca)

Zone		June	Dec.
I:	N. Jutland	0.8±0.1	0.7±0.1
II:	E. Jutland	1.5±0.1	1.0±0.1
III:	W. Jutland	0.8±0.2	0.9±0.0
IV:	S. Jutland	0.9±0.1	0.9±0.1
V:	Funen	1.1±0.1	0.8±0.1
VI:	Zealand	1.4±0.0	1.2±0.1
VII:	Lolland-Falster	1.5±0.1	2.1±0.1
VIII:	Bornholm	0.7±0.1	0.7±0.1
Mean		1.1	1.0
Copenhagen		1.1±0.1	1.3±0.1

S.U. in total diet since May 1961. Figure 5.7.2 shows the daily ^{137}Cs intake since June 1963.

The 1974 ^{90}Sr levels in total diet were approximately equal to the 1973 levels, while the ^{137}Cs levels were approximately 20% higher than the 1973 ones.

From the total-diet sampling it is possible to estimate the mean levels of ^{90}Sr and ^{137}Cs in the Danish diet in 1974. For the period January-April 1974 the ^{90}Sr level in the total diet is assumed to have been equal to that measured in December 1973, Risø Report No. 305[1]. For the period May-September we assume the level to have corresponded to that measured in June 1974. The December 1974 figure is taken to represent the last three months of the year. The population-weighted mean of ^{90}Sr in total-diet samples was 6.8 pCi ^{90}Sr/g Ca in December 1973. Hence the mean content in the total diet in 1974 was 7.1 pCi ^{90}Sr/g Ca or 12.0 pCi ^{90}Sr/day.

In a similar way the ^{137}Cs content in the Danish diet in 1974 was estimated to be 19 pCi ^{137}Cs/day or 4.4 pCi ^{137}Cs/g K (cf. also Appendix C).

5.8. Strontium-90 and Caesium-137 in Miscellaneous Foodstuffs

5.8.1. Strontium-90 and Caesium-137 in Meat

Pork and beef samples were collected in Copenhagen in three large shops in June, September, and December. Table 5.8.1 shows the results. Figures 5.8.1.1 - 5.8.1.4 show a comparison between milk and meat levels. The ratio (pCi ^{90}Sr/kg meat)/(pCi ^{90}Sr/l milk) was 0.21 (S.E. 0.03), and the corresponding ratio for ^{137}Cs was 4.8 (S.E. 0.3) for the period 1962-1974. (In these calculations meat consisted of 2/3 pork and 1/3 beef) (cf. also Appendix C).

Table 5.8.1

Strontium-90 and Caesium-137 in pork and beef from Copenhagen in 1974

Species	Unit	June	Sep.	Dec.	Mean
Pork	pCi ^{90}Sr/kg	1.19 B	2.89	2.60 B	2.22
	pCi ^{90}Sr/g Ca	10.5 B	16	38 B	22
	pCi ^{137}Cs/kg	14 A	20 A	62	32
	pCi ^{137}Cs/g K	4.8 A	6.2 A	23	11
Beef	pCi ^{90}Sr/kg	3.05	2.89 A	3.94 A	3.29
	pCi ^{90}Sr/g Ca	17	27 A	27 A	24
	pCi ^{137}Cs/kg	37	26 A	9.9 A	24
	pCi ^{137}Cs/g K	13	8.0 A	3.3 A	8

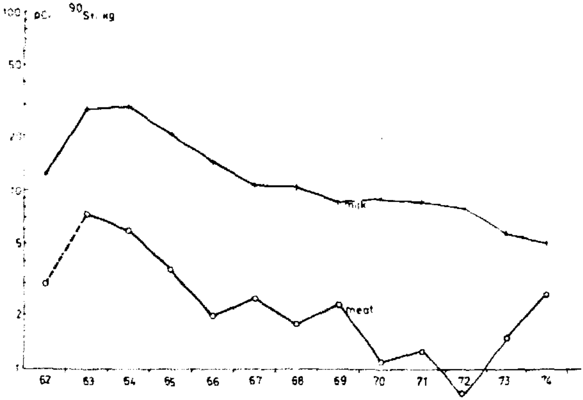

Fig. 5.8.1.1. Strontium-90 in Danish milk and meat (2/3 pork and 1/3 beef) 1962-74.

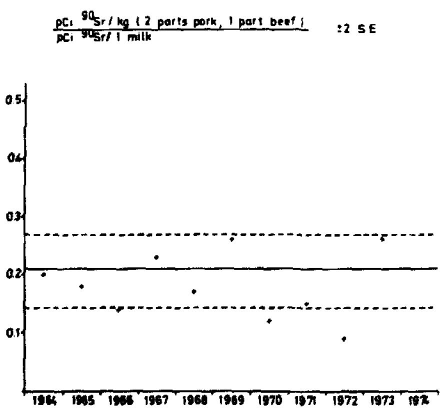

Fig. 5.8.1.2. The ratio between ^{90}Sr in Danish meat and milk 1964-74.

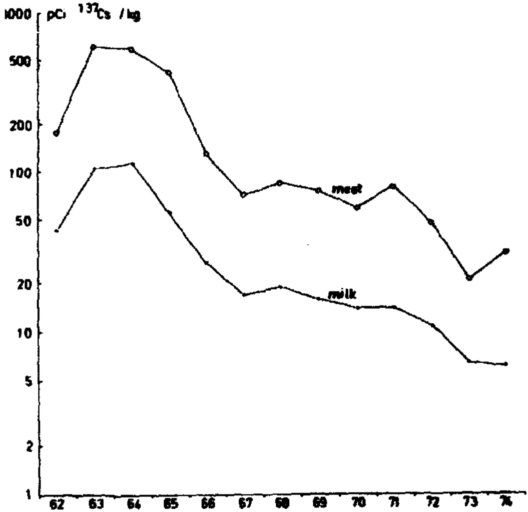

Fig. 5.8.1.3. Caesium-137 in Danish milk and meat (2/3 pork and 1/3 beef) 1962-74.

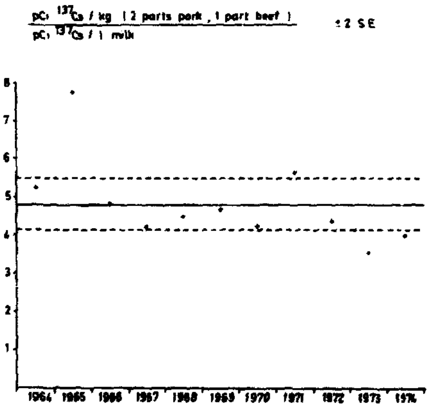

Fig. 5.8.1.4. The ratio between ^{137}Cs in Danish meat and milk 1964-74.

5.8.2. Strontium-90 and Caesium-137 in Fish

Fish samples were collected in inner Danish waters together with the sea-water samples (cf. 7). Table 5.8.2 shows the results. The mean levels in fish from 1974 were 73 pCi ^{137}Cs/kg (4 samples) and 1.3 pCi ^{90}Sr/kg (4 samples).

Table 5.8.2

Strontium-90 and Caesium-137 in fish collected in the Sound and Roskilde Fjord in December 1974

			^{90}Sr pCi/kg	^{90}Sr pCi/g Ca	^{137}Cs pCi/kg	^{137}Cs pCi/g K
Cod	The Sound	Meat	1.76	1.58	125.0	26.6
	Tårbæk rev	Bone	-	0.83	-	-
Herring	The Sound	Meat	1.39	1.43	48.9	12.3
	North part	Bone	-	0.19 B	-	-
Flounder	The Sound	Meat	0.28 B	0.30 B	71.0	19.1
	Tårbæk rev	Bone	-	0.86	-	-
Eel	Roskilde	Meat	1.13	3.58	44.9	15.9
	Fjord	Bone	-	1.09	-	-

5.8.3. Drinking Water

No samples of drinking water were analysed in 1974.

5.8.4. Strontium-90 and Caesium-137 in Various Foods

As compared with the corresponding sampling in 1972[1], the ^{137}Cs levels in coffee as well as tea have decreased 3 to 4 times. The ^{90}Sr levels

Table 5.8.4

Strontium-90 and Caesium-137 in various foods collected in December 1974

	pCi ^{90}Sr/kg	S.U.	pCi ^{137}Cs/kg	M.U.	nSr mg/g Ca
Mushroom	0.53 A	9.4 A	5.2	1.6	2.1
Orange	8.9	19.7	4.4	3.0	0.4
Lemon	7.5	22.5	5.3	2.6	6.8
Grape	4.19	1.5	0	0	1.1
Rice	0.50 A	0.66 A	0	0	0
Banana	5.7 B	0.75 B	0	0	1.5
Coffee	15.3	1.01	9.3 B	0.64 B	16.0
Tea	44.7	5.26	92	6.4	23.4

in coffee, tea, orange, lemon, grape and banana are on the other hand unchanged or a little higher. Mushrooms contained a relatively high ^{137}Cs level, especially when considering they were grown indoors.

The stable Sr levels in coffee and tea correspond to the levels found in 1972[1].

5.9. Estimate of the Mean Contents of ^{90}Sr and ^{137}Cs in the Human Diet in Denmark in 1974

5.9.1. The Annual Quantities

The annual quantities are calculated by multiplication of the daily quantities by 365 (as stated by E. Hoff-Jørgensen, cf. Risø Report No. 63, table B[1]).

Table 5.9.1

Estimate of the ^{90}Sr content in grain products consumed per capita in 1974

Type	Fraction from harvest 1973			Fraction from harvest 1974			Total
	kg flour	pCi/kg	pCi	kg flour	pCi/kg	pCi	pCi
Rye flour (100% extraction)	21.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wheat flour (75% extraction)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grits	[illegible]	[illegible]	[illegible]	1.8	[illegible]	[illegible]	[illegible]
Total	60.3	12.8	774	20.0	16.5	330	1104

5.9.2. Milk and Cream

The ^{90}Sr and ^{137}Cs contents per kg milk were calculated from the annual mean values for dried milk (cf. tables 5.1.1 and 5.1.3). 1 kg ~ 1 l milk, containing approx. 1.2 g Ca and 1.66 g K. Hence the mean contents in milk were 5.4 pCi ^{90}Sr/kg and 7.3 pCi ^{137}Cs/kg.

Table 5.9.2

Estimate of the ^{137}Cs content in grain products consumed per capita in 1974

Type	Fraction from harvest 1973			Fraction from harvest 1974			Total
	kg flour	pCi/kg	pCi	kg flour	pCi/kg	pCi	pCi
Rye flour (100% extraction)	21.9	11.8	259	7.3	51	372	631
Wheat flour (75% extraction)	32.9	3.8	125	10.9	15.5	169	294
Grits	5.5	8.8	48	1.8	28.2	51	99
Total	60.3	7.2	432	20.0	29.6	592	1024

Table 5.9.3

Estimate of the mean content of ^{90}Sr in the human diet in Denmark in 1974

Type of food	Annual quantity in kg	pCi ^{90}Sr per kg	Total pCi ^{90}Sr	Percentage of total pCi ^{90}Sr in food
Milk and cream	[illegible]	[illegible]	886	[illegible]
Cheese	9.1	[illegible]	349	9.9
Grain products	[illegible]	[illegible]	[illegible]	31.3
Potatoes	[illegible]	[illegible]	234	6.6
Vegetables	[illegible]	[illegible]	[illegible]	12.7
Fruit	51.1	[illegible]	204	5.8
Meat	54.7	2.6	142	4.0
Eggs	[illegible]	1.3	14	0.4
Fish	[illegible]	1.3	14	0.4
Coffee and tea	[illegible]	24.3	137	3.9
Drinking water	549	0.02	11	0.3
Total			3574	

The mean calcium intake was estimated at [illegible] g (approx. 240-250 g Creta praeparata). Hence the $^{90}Sr/Ca$ ratio in the total diet was 5.7 S.U. in 1974.

5.9.3. Cheese

One kg of cheese contains approx. 8.5 g Ca and 1.2 g K. The ^{90}Sr and ^{137}Cs contents in cheese were calculated from these figures and from the S.U. and M.U. levels in dried milk (cf. tables 5.1.1 and 5.1.3). One kg of cheese appeared to contain 38.3 pCi ^{90}Sr and 5.3 pCi ^{137}Cs.

5.9.4. Grain Products

Tables 5.9.1 and 5.9.2 show the estimates of ^{90}Sr and ^{137}Cs respectively in grain products consumed in 1974. From these tables the activity levels in grain products were estimated at 13.8 pCi ^{90}Sr/kg and 12.8 pCi ^{137}Cs/kg.

Table 5.9.4

Estimate of the mean content of ^{137}Cs in the human diet in Denmark in 1974

Type of food	Annual quantity in kg	pCi ^{137}Cs per kg	Total pCi ^{137}Cs	Percentage of total pCi ^{137}Cs in food
Milk and cream	[illegible]	[illegible]	[illegible]	[illegible]
Cheese	9.1	5.3	48	0.8
Grain products	[illegible]	10.4	[illegible]	[illegible]
Potatoes	[illegible]	6.3	[illegible]	[illegible]
Vegetables	[illegible]	1.9	[illegible]	1.5
Fruit	[illegible]	4.0	204	3.6
Meat	[illegible]	[illegible]	[illegible]	[illegible]
Eggs	[illegible]	[illegible]	[illegible]	[illegible]
Fish	[illegible]	[illegible]	796	14.1
Coffee and tea	[illegible]	[illegible]	[illegible]	3.6
Drinking water	[illegible]	0	0	0
Total			5651	

As the approximate intake of potassium was 1365 g, the pCi $^{137}Cs/g$ K ratio was approx. 4.1. The daily mean intake in 1974 was 15 pCi ^{137}Cs per capita.

5.9.5. Potatoes

The figures in table 5.5.1 were used, i.e. 3.2 pCi $^{90}Sr/kg$ and 6.3 pCi $^{137}Cs/kg$.

5.9.6. Vegetables

Table 5.6.5 shows the calculation of ^{90}Sr and ^{137}Cs in Danish vegetables consumed in 1974. The mean contents were 9.8 pCi $^{90}Sr/kg$ and 1.9 pCi $^{137}Cs/kg$.

5.9.7. Fruit

The levels in imported fruit in 1974 are assumed to be equal to the mean levels found in lemons, oranges, grapes and bananas collected in Copenhagen in 1974, i.e. 6.6 pCi $^{90}Sr/kg$ and 2.4 pCi $^{137}Cs/kg$. The mean levels in Danish fruit (apples) in 1974 were 3.0 pCi $^{90}Sr/kg$ and 4.7 pCi $^{137}Cs/kg$ (cf. 5.6). The daily mean consumption of fruit consisted of 100 g of Danish and 40 g of foreign origin. Hence the mean contents in fruit were 4.0 pCi $^{90}Sr/kg$ and 4.0 pCi $^{137}Cs/kg$.

5.9.8. Meat

The annual mean values of ^{90}Sr and ^{137}Cs in meat were calculated from table 5.8.1: 2.6 pCi ^{90}Sr/kg and 29.3 pCi ^{137}Cs/kg. (Danish meat consists of 2/3 pork and 1/3 beef).

5.9.9. Fish

The ^{90}Sr and ^{137}Cs contents in fish are estimated from 5.8.2 at 1.3 pCi ^{90}Sr/kg and 73 pCi ^{137}Cs/kg (mean of all fish samples collected in 1974).

5.9.10. Eggs

The activity contents in eggs were estimated from a 1974 sample collected in Copenhagen. The levels were 1.3 pCi ^{90}Sr/kg and 3 pCi ^{137}Cs/kg.

5.9.11. Coffee and Tea

One third of the total consumption consists of tea and two thirds of coffee. The mean contents from 1974 were used: 24.9 pCi ^{90}Sr/kg and 36.9 pCi ^{137}Cs/kg.

5.9.12. Drinking Water

The ^{90}Sr level (population-weighted mean) found in drinking water collected in June 1973 was used as the mean level for drinking water, i.e. 0.02 pCi ^{90}Sr/l. The ^{137}Cs content in drinking water is assumed to be negligible, because it cannot be detected even in surface fresh water (cf. 4.4).

5.9.13. Discussion

Tables 5.9.3 and 5.9.4 show the estimates of ^{90}Sr and ^{137}Cs in the Danish diet in 1974. The figures should be compared with the levels calculated from the total-diet samples (cf. 5.7). The ^{90}Sr estimates obtained by the two methods were 5.7 S.U. and 7.1 S.U. respectively, and the ^{137}Cs estimates were 15 pCi ^{137}Cs/day and 19 pCi ^{137}Cs/day. The deviations between the two estimates are partly ascribed to the disagreement between the actual levels in bread and those calculated from grain (cf. table 5.4.3).

The relative contributions of ^{90}Sr from milk products (~35%) and from grain (31%) were nearly unchanged compared with 1973. The contribution from potatoes, other vegetables, and fruit was 24.6%, i.e. also unchanged from 1973. The relative contribution of ^{137}Cs in the total diet changed as follows from 1973 to 1974: milk products were a little higher (19 to 22%), grain products decreased from 25 to 18%, and meat was higher (21 to 28%).

6. STRONTIUM-90 AND CAESIUM-137 IN MAN IN 1974

6.1. Strontium-90 in Human Bone

The collection of human vertebrae from the institutes of forensic medicine in Copenhagen and Århus was continued in 1974. As in the total-food survey (cf. 5.7), the country was divided into eight zones. The samples were divided into five age groups: new-born (< 1 month), infants (1 month-4 years), children and teenagers (5 - 19 years), adults (≤ 29 years) and adults (> 29 years).

Tables 6.1.1 - 6.1.5 show the results for the five groups.

The levels were generally lower in 1974 than in 1973. The highest mean level in vertebrae was found in infants, but the levels in the different age groups were not much different.

Table 6.1.1

Strontium-90 in bone from new-born children (< 1 month old) in 1974

Zone	Age in days	Month of death	Sex	pCi ^{90}Sr/g Ca
VI	7	4	M	1.46
VI	~0	~6	F	1.06[x]

[x] 2 samples combined in one analysis

Table 5.1.2

Strontium-90 in bone from infants ($\leq$ 4 years old) in 1974

Zone	Age in years and months	Month of death	Sex	pCi ^{90}Sr/g Ca
I	[illegible] m	[illegible]	F	2.[illegible]9
I	8 m	3	M	4.0[illegible]
II	10 m	3	F	2.39
II	4 m	4	F	1.5[illegible]
II	3 m	[illegible]	M	1.55
II	1 m	8	F	2.[illegible]3
II	4 y	6	F	1.[illegible]9
II	4 y	[illegible]	M	1.[illegible] A
II	~[illegible] m	~5	M	1.34*
III	3 m	4	M	2.13 B
III	10 m	11	F	1.54
IV	6 m	7	F	1.6[illegible] A
VI	1 y 4 m	1	M	1.49 A
VI	3 m	[illegible]	F	0.93 A
VI	2 y 6 m	[illegible]	M	1.4[illegible]
VI	1 y 1 m	[illegible]	F	1.7[illegible] B
VI	9 m	3	F	1.76 B
VI	3 y 6 m	8	M	2.[illegible]
VI	~4 m	~8	F	1.[illegible]*
VI	~2 y	~3	F	1.7[illegible]$^{\Delta}$
VI	~8 m	~3	F	1.8[illegible]$^{\nabla}$
VI	~1 y	~3	F	1.35*
VI	~2 m	~5	M	1.11**

*2 samples combined in one analysis

$^{\nabla}$3 samples combined in one analysis

$^{\Delta}$5 samples combined in one analysis

**7 samples combined in one analysis

Table [illegible]

Strontium-90 in bone from children and teenagers (≤ 19 years) in 1974

Zone	Age in years	Month of death	Sex	pCi ^{90}Sr/g Ca
I	19	1	M	1.33
I	16	4	M	1.19
I	16	[illegible]	M	1.28
I	18	5	M	1.93
II	13	7	F	1.06 A
II	16	7	F	1.00 A
II	16	11	F	1.58
II	13	8	M	1.02
II	9	10	M	1.26 A
II	11	9	M	1.39
III	17	9	F	1.41 A
III	16	7	M	1.18
III	19	5	M	1.15
VI	5	1	F	1.20 A
VI	15	1	F	1.63
VI	19	2	F	1.06
VI	17	7	F	0.70 A
VI	16	9	F	1.69
VI	17	1	M	1.14 A
VI	7	1	M	1.84
VI	15	1	M	1.05
VI	16	2	M	1.06
VI	17	7	M	1.50
VI	17	6	M	0.87 B
VI	7	3	M	1.21
VI	15	11	M	0.83
VI	19	1	M	1.40
VI	14	6	M	0.98
VI	18	8	M	1.02
VI	15	8	M	1.45 A
VI	16	10	M	1.69
VI	18	3	M	2.74
VI	10	3	M	2.26
VI	16	5	M	3.60
VI	19	6	M	1.63
VI	18	9	M	1.04
VI	18	8	M	1.05 B
VI	16	10	M	1.14
VIII	17	11	F	1.16

Table 5.1.4

Strontium-90 in vertebrae from adults (≤ 29 years) in 1974

Zone	Age in years	Month of death	Sex	pCi ^{90}Sr/g Ca
I	21	9	M	1.55
II	23	4	F	1.53
II	24	6	F	1.55
II	22	11	F	1.30
II	28	7	M	0.98
II	20	9	M	1.11
II	24	10	M	1.30
II	24	3	M	1.18
III	20	5	F	2.04
III	28	6	M	1.70
III	24	5	M	1.71
IV	22	6	M	1.34
VI	24	7	F	1.20
VI	22	4	F	0.74 A
VI	29	8	F	1.32
VI	20	10	F	1.63
VI	22	1	F	1.48 A
VI	21	9	F	1.84
VI	23	9	F	1.67
VI	21	9	F	1.07
VI	20	11	F	1.41
VI	22	2	M	1.24
VI	21	7	M	1.31 A
VI	25	4	M	1.27 A
VI	25	8	M	0.19 A
VI	28	10	M	0.76 B
VI	28	10	M	0.87
VI	21	11	M	1.53
VI	23	11	M	1.39
VI	25	11	M	1.64
VI	21	7	M	1.35
VI	26	7	M	1.08
VI	28	3	M	0.96
VI	21	3	M	1.39
VI	27	9	M	1.08 A
VI	21	8	M	1.10
VI	24	9	M	1.09
VI	20	9	M	1.11 A
VI	23	10	M	0.94

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I	[illegible]	3	F	[illegible]
I	[illegible]	1	F	1.36
I	64	8	F	[illegible] A
I	52	6	F	[illegible]
I	53	[illegible]	F	[illegible] A
I	58	7	M	1.49
I	62	4	M	1.33
[illegible]	49	8	M	1.27
I	84	1	M	1.51
I	63	3	M	1.84
I	65	5	M	1.67
I	52	5	M	1.16
I	51	6	M	1.96
II	63	7	F	1.35
II	55	4	F	1.28
II	49	1	F	0.96
II	46	7	F	2.76
II	61	10	F	1.49
II	55	11	F	1.29
II	52	6	F	1.63
II	74	6	F	1.92
II	52	6	F	1.50
II	71	2	M	1.78
II	30	2	M	1.40
II	47	2	M	1.08
II	41	3	M	1.27
II	38	11	M	1.96
II	37	3	M	1.25
II	67	1	M	0.92
II	72	6	M	1.61
II	54	7	M	0.93
II	46	7	M	0.96
II	78	9	M	1.18
II	39	8	M	1.21
II	[illegible]	8	M	1.34
II	52	5	M	1.91
II	35	5	M	1.66
II	30	5	M	2.17
III	38	3	F	1.65
III	54	3	F	1.43
III	58	3	F	1.24
III	60	3	F	1.59
III	73	8	F	1.63
III	69	6	F	1.34
III	75	7	M	2.78
III	39	3	M	1.23
III	33	4	M	1.38
III	52	4	M	1.67
III	62	8	M	1.95
III	59	11	M	2.64
III	62	1	M	1.39
III	45	7	M	1.41
III	58	7	M	1.27
III	40	9	M	2.05
III	57	9	M	1.86
IV	64	7	M	0.72
VI	39	3	F	2.66
VI	45	1	F	1.43
VI	45	9	F	1.13 A
VI	31	11	F	1.41
VI	41	4	M	1.05
VI	31	8	M	0.94
VI	31	7	M	1.96
VI	36	5	M	2.00

Table 6.1.[illegible]

Strontium-90 (pCi/g Ca) in human vertebrae collected in Denmark in [illegible]

Age group	Number of samples	Number of analysis	Min.	Max.	Median	Mean of analysis	Sample number weighted mean
New-born (< 1 month)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Infants (≤ 4 years)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Children (≤ 19 years)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Adults (≤ 29 years)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Adults (≥ 30 years)	64	64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

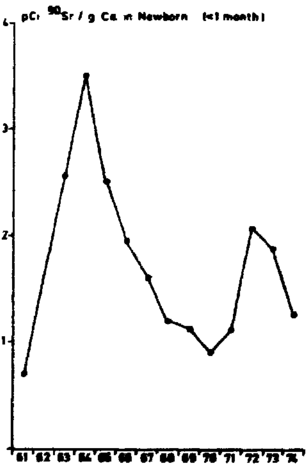

Fig. 6.1.1. Strontium-90 in bone from newborn 1961-74.

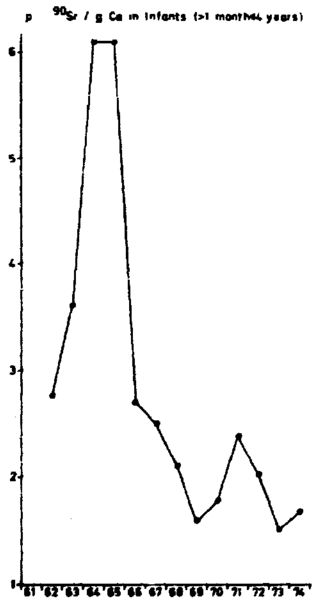

Fig. 6.1.2. Strontium-90 in bone from infants 1962-74.

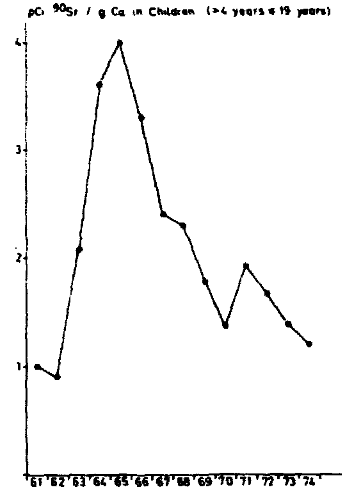

Fig. 6.1.3. Strontium-90 in bone from children 1961-74.

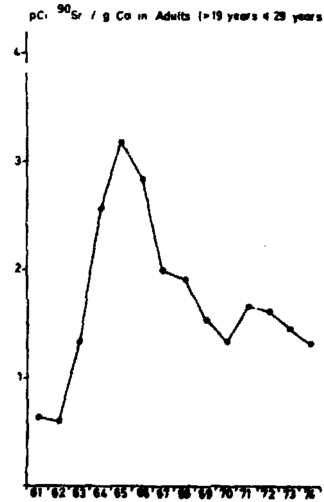

Fig. 6.1.4. Strontium-90 in vertebrae from adults ≤ 29 y, 1961-74.

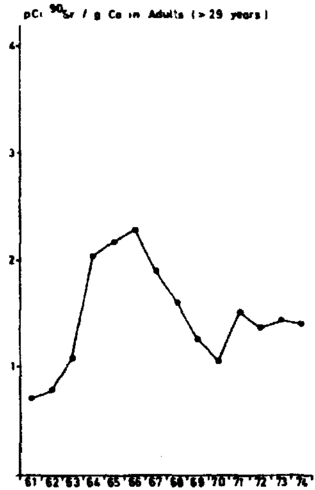

Fig. 6.1.5. Strontium-90 in vertebrae from adults) 29 y, 1961-74.

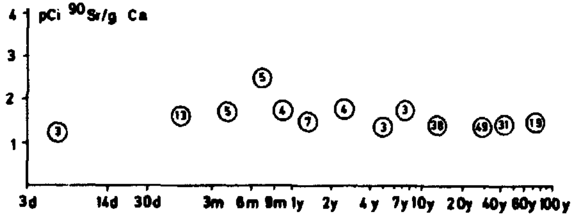

Fig. 6.1.6. Strontium-90 in human vertebrae in 1974 (the figures in the circles indicate the number of samples).

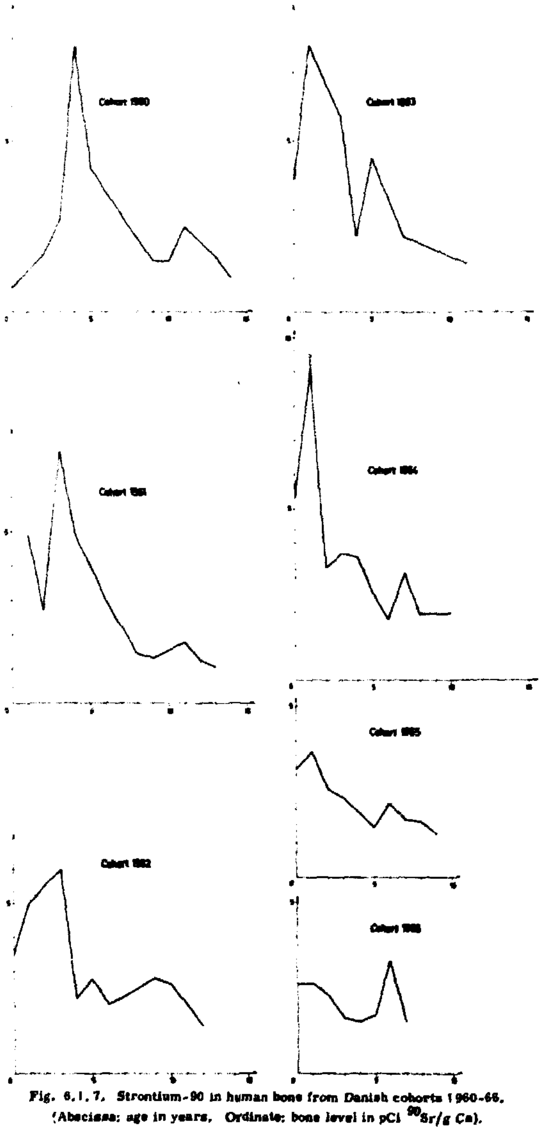

Fig. 6.1.7. Strontium-90 in human bone from Danish cohorts 1960-66. (Abscissa: age in years, Ordinate: bone level in pCi $^{90}Sr/g$ Ca).

6.2. Caesium-137 in the Human Body

In July 1963 whole-body measurements were initiated at Risø in the low-level counting room in the Health Physics Department (cf. 2.3 in Risø Report No. 85[1]). A control group from the Health Physics Department was selected and has since then been measured three times a year. Table 6.2 shows the results.

The annual mean value of the control group was 9.6 pCi ^{137}Cs/g K. As earlier, we shall consider this figure representative of the mean of the Danish population in 1974. The total-body content of ^{137}Cs in 1973 for a standard man containing 140 g of potassium equals $140 \cdot 9.6 \cdot 10^{-3}$ nCi = 1.3 nCi ^{137}Cs, i.e. 87% of the 1973 level.

Figure 6.2 shows the mean M.U. values (with one S.D.) for men and women measured in 1963-1974.

The maximum was reached in August 1964. The figure also shows that the mean level in the male group was approx. 1.3 - 1.5 times as high as that in the female group.

[illegible]

[illegible]

No.	Sex	[illegible]	Age	Height in cm	Weight in kg	[illegible]	pCi [illegible] kg	g K/kg [illegible]
1	F	April	[illegible]	165	57	[illegible]	26.7	[illegible]
[illegible]	F	-	42	170	63	14.6	56.0	1.4
[illegible]	F	-	44	[illegible]	66	[illegible]	[illegible]	1.5
[illegible]	M	-	[illegible]	[illegible]	87	[illegible]	[illegible]	2.4
15	F	-	[illegible]	161	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	M	-	[illegible]	174	73	6.9	[illegible]	2.2
[illegible]	M	-	42	[illegible]	67	7.4	[illegible]	[illegible]
[illegible]	F	-	53	176	63	4.9	[illegible]	1.6
[illegible]	M	-	[illegible]	183	74	[illegible]	[illegible]	[illegible]
[illegible]	M	-	43	170	76	[illegible]	39.9	2.3
[illegible]	M	-	28	168	62	7.7	18.4	2.4
[illegible]	F	-	45	157	59	[illegible]	3.7	1.8
33	M	-	43	184	63	2.1	[illegible]	2.4
34	M	-	32	177	73	3.9	8.9	2.3
35	M	-	33	181	74	11.4	24.4	2.1
[illegible]	M	-	[illegible]	167	70	15.0	21.2	2.1
51	M	-	42	175	86	6.5	12.9	2.0
52	F	-	37	170	55	5.6	11.8	2.1
53	F	-	49	154	85	1.1	1.5	1.4
1	F	Aug.	24	167	57	8.5	17.3	1.6
2	F	-	25	165	52	57.6	131.3	1.9
4	[illegible]	-	50	161	61	3.7	5.4	1.5
7	F	-	46	171	55	7.0	17.8	1.8
8	M	-	42	193	79	18.0	32.[illegible]	1.8
12	M	-	36	176	74	11.5	22.9	2.0
15	F	-	38	165	52	7.3	13.3	1.8
19	M	-	35	178	76	7.9	15.1	1.9
20	M	-	42	172	66	11.6	22.9	2.0
24	M	-	43	170	75	19.1	39.8	2.1
25	F	-	32	167	57	0.6	0.8	1.6
26	F	-	35	160	55	3.2	4.7	1.5
30	M	-	28	168	58	7.5	17.6	2.3
31	M	-	32	182	72	17.6	37.9	2.2
32	F	-	45	157	64	5.4	9.3	1.5
33	M	-	43	184	62	8.2	19.8	2.4
34	M	-	32	177	73	7.0	18.6	2.4
[illegible]	M	-	33	181	70	13.4	26.2	2.0
44	F	-	24	179	57	2.8	4.8	1.8
48	F	-	35	162	50	5.7	12.0	2.1
50	M	-	28	169	63	2.2	5.0	2.3
53	F	-	49	154	81	0.3	0.5	1.4
54	F	-	33	163	60	2.1	3.2	1.5
97	M	-	53	195	109	14.8	25.5	1.7
2	F	Dec.	25	165	50	22.6	41.4	1.8
4	F	-	52	163	58	6.9	11.7	1.7
7	F	-	46	171	63	7.1	11.5	1.6
8	M	-	42	193	80	23.0	42.0	1.8
12	M	-	36	176	74	4.6	9.2	2.0
19	M	-	32	174	72	2.0	6.1	2.0
21	F	-	53	176	63	0.7	1.2	1.6
23	M	-	44	192	85	4.6	12.5	1.9
24	M	-	43	170	76	13.6	27.4	2.0
30	M	-	28	168	60	8.0	13.0	2.2
32	F	-	45	157	64	1.9	3.1	1.6
33	M	-	43	184	62	3.7	8.5	2.3
34	M	-	32	177	70	6.2	18.3	2.3
35	M	-	33	181	70	6.2	16.0	1.9
43	M	-	57	167	70	7.8	15.2	1.9
44	F	-	24	170	55	1.7	3.0	1.7
45	F	-	27	167	60	9.5	20.8	2.2
48	F	-	35	162	50	14.2	27.2	1.9
50	M	-	26	169	68	8.9	18.7	2.2
53	F	-	49	154	88	28.9	39.7	1.4

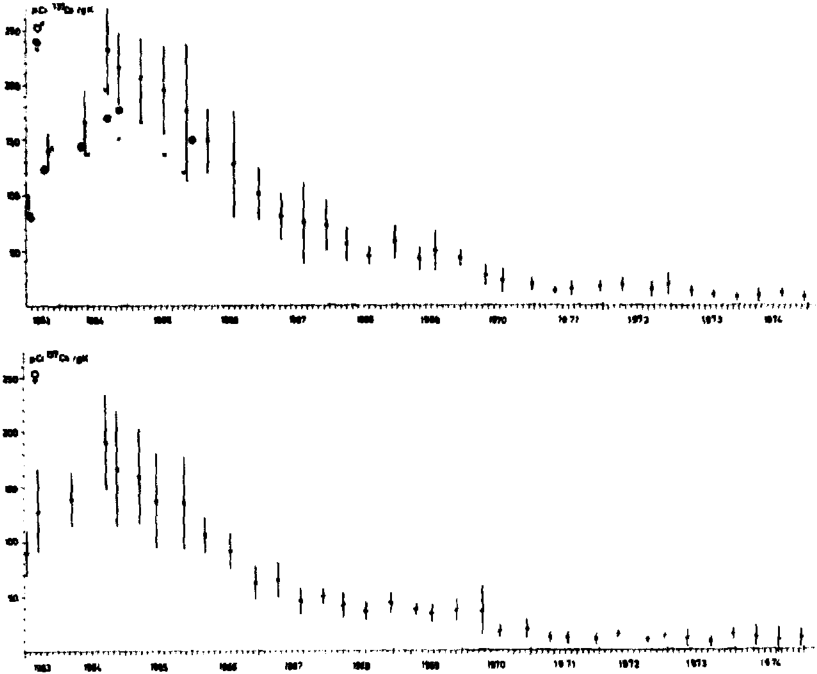

Fig. 6.2. Caesium-137 mean levels in humans, 1963-74 (1 S.D. indicated).

7. STRONTIUM-90 AND CAESIUM-137 IN SEA WATER IN 1974

As in previous years, seawater samples were collected by M/S Fyrholm in the summer and late autumn from inner Danish waters (cf. table 7.1 and figs. 7.1 and 7.2). Furthermore, seawater samples were collected at Barsebäck in the Sound (table 7.2), at Ringhals in the Cattegat (table 7.3),

Table 7.1

Strontium-90 and Caesium-137 in sea water collected around Zealand in May and November 1974

	Position		May				November			
	N	E	depth in m	^{90}Sr pCi/l	Salinity o/oo	^{137}Cs pCi/l	depth in m	^{90}Sr pCi/l	Salinity o/oo	^{137}Cs pCi/l
Kullen	56°15'	12°25'	0	0.74	12.7	0.72	0	0.91	11.7	0.83
"			21	0.60	34.2	1.21	22	0.73	34.2	1.15
Hesselø	56°10'	11°47'	0	0.74	17.9	0.86	0	0.68	22.5	1.18
"			28	0.61	34.4	1.09	23	0.69	26.4	1.09
Kattegat SW	56°07'	11°10'	0	0.83	15.[illegible]	0.75	0	0.73	20.7	1.12
"			33	0.56	31.4	0.92	33	-	33.4	1.11
Asnæs rev	55°38'	10°47'	0	0.86	12.5	0.78	0	-	17.2	0.70
" "			43	0.47	29.8	1.05	47	-	31.7	1.09
Halskov rev	55°20'	11°02'	0	0.91	13.5	0.85	0	0.94	12.8	0.69
" "			50	0.63	29.6	1.12	47	0.65	24.2	0.98
Langeland bælt	54°52'	10°50'	0	0.81	11.3	0.51	0	-	15.7	0.85
" "			47	0.69	26.7	1.09	45	-	26.8	0.90
Femern bælt	54°36'	11°05'	0	0.87	12.2	0.71	0	0.83	12.6	0.74
" "			25	0.56	24.6	1.15	24	0.72	12.5	0.41
Gedser rev	54°28'	12°13'	0	0.90	9.0	0.73	0	1.00	10.2	0.76
" "			26	0.64	20.7	0.83	25	0.94	8.3	0.81
Møen	54°57'	12°41'	0	0.74	9.3	0.76	0	0.73	8.4	0.92
"			20	0.65	8.8	0.78	20	0.84	9.1	0.58
The Sound - south	55°25'	12°39'	0	0.80	7.8	0.61	0	-	-	0.59
" " "			12	0.98	7.3	0.48	13	-	10.0	0.55
The Sound - north A	55°48'	12°44'	0	0.75	10.6	0.87	0	0.98	9.0	0.75
" " "			21	0.63	37.4	1.21	20	-	33.6	1.05
The Sound - north B	55°59'	12°42'	0	0.82	10.1	0.73	0	-	9.5	0.63
" " "			25	0.61	33.8	1.25	26	-	33.7	1.00
Mean				0.81	11.9	0.74		0.85	13.7	0.81
SD			Surface	0.06	2.8	0.10		0.12	1.4	0.18
SE				0.02	0.8	0.03		0.04	4.8	0.05
Mean				0.63	26.1	1.02		0.76	22.8	0.89
SD			Bottom	0.12	9.3	0.23		0.11	10.7	0.25
SE				0.04	2.7	0.06		0.04	3.2	0.07

Table 7.2

Strontium-90 and Caesium-137 in sea water collected in the Sound (Barsebäck) in 1974

Position N	Position E	April depth in m	April ^{90}Sr pCi/l	April ^{137}Cs pCi/l	April Salinity o/oo	June depth in m	June ^{90}Sr pCi/l	June ^{137}Cs pCi/l	June Salinity o/oo	November depth in m	November ^{90}Sr pCi/l	November ^{137}Cs pCi/l	November Salinity o/oo
55°42'08"	12°54'	0	0.60	0.70	7.7	0	0.83	0.85	8.2	0	-	0.64	9.0
- " -	- " -	14	-	1.09	31.8	14	0.57	1.09	31.4	14	-	1.04	33.2
55°47'05"	12°51'07"	0	0.81	0.71	8.3	0	0.92	0.82	8.4	0	-	0.71	-
- " -	- " -	16	0.69	1.16	32.4	16	0.68	1.33	32.8	16	-	1.14	-
Mean		Surface	0.71	0.71	8.0	Surface	0.88	0.84	8.3	Surface	-	0.68	9.0
SD			0.15	0.01	0.4		0.06	0.02	0.1		-	0.05	-
SE			0.11	0.01	0.3		0.05	0.01	0.1		-	0.04	-
Mean		Bottom	0.69	1.13	32.1	Bottom	0.63	1.21	32.1	Bottom	-	1.09	33.2
SD			0	0.05	0.4		0.08	0.17	1.0		-	0.07	-
SE			0	0.04	0.3		0.06	0.12	0.7			0.05	-

Table 7.3

Caesium-137 in sea water collected at Ringhals in October 1974

Position		depth in m	^{137}Cs pCi/l	Salinity o/oo
N	E			
57°15'05"	12°06'	0	0.83±0.02	21.6
- " -	- " -	17	1.06±0.10	28.6
57°13'03"	12°03'04"	0	0.92±0.06	20.4±0.0
- " -	- " -	27	1.01±0.01	34.1±1.1
57°14'	11°53'06"	0	0.82±0.00	20.0±0.1
- " -	- " -	73-76	1.04±0.05	33.6±1.5
Mean		Surface	0.86	20.7
SD			0.06	0.8
SE			0.03	0.5
Mean		Bottom	1.04	32.1
SD			0.03	3.0
SE			0.01	1.8

and at Gyllingnæs in the Aarhus Bay (table 7.6). The DANA took samples in the North Sea and the Skagerak in February (table 7.4) and in July-August (table 7.5).

In Risø Report No. 305[1] it was suggested that the increasing ^{90}Sr and ^{137}Cs levels observed in 1973 in inner Danish waters were due to contamination from inflow of water from the North Sea contaminated with ^{137}Cs and ^{90}Sr from nuclear plants in the UK and France. The increase continued in 1974 as shown in table 7.1 and fig. 7.1, and it is now evident that the ^{137}Cs and ^{90}Sr originate from the North Sea.

The ^{90}Sr concentration has especially increased in sea water of high salinity as shown in the following regression equations:

$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.94 - 0.018 \text{ o/oo} \quad (1967\text{-}71)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.97 - 0.020 \text{ o/oo} \quad (1972)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.95 - 0.014 \text{ o/oo} \quad (1973)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.93 - 0.010 \text{ o/oo} \quad (1974)$$

(The regression analysis showed significant or probably significant regression in all cases except in 1973).

The mean salinities of sea water from the Baltic and the Norgh Sea are approx. 10 o/oo and 33 o/oo respectively[1]. From the above equations

Table 7.4

Strontium-90 and Caesium-137 in surface sea water collected in the North Sea, Skagerak and Kattegat in February 1974

Position	pCi ^{90}Sr/l	pCi ^{137}Cs/l	Salinity o/oo
58°10'N 02°21'E	0.21	0.38	34.4
57°30'N 04°10'E	0.34	0.36	34.2
53°23'N 02°45'E	1.05	1.96	32.2
57°05'N 11°41'E	0.73	1.07	21.9
53°24'N 03°18'E	0.59	0.83	34.2
57°52'N 09°41'E	0.71	1.44	34.8
56°34'N 06°52'E	0.76	1.71	34.0
59°35'N 00°47'E	0.17	0.27 A	34.4
54°24'N 04°45'E	1.05	1.91	33.9
59°13'N 01°44'E	0.24	0.13 B	34.2
55°58'N 06°21'E	-	1.27	34.2
57°33'N 08°46'E	-	1.67	34.2
55°56'N 07°50'E	-	1.30	31.5
55°19'N 07°31'E	0.69	1.33	29.8
58°46'5"N03°38'E	-	0.71	30.4
56°13'N 04°38'E	-	2.19	34.0
Mean	0.59	1.16	32.6
SD	0.32	0.65	3.2
SE	0.10	0.16	0.8

Table 7.5

Strontium-90 and Caesium-137 in surface sea water collected in the North Sea, Skagerak and Kattegat in July-August 1974

Position	pCi ^{90}Sr/l	pCi ^{137}Cs/l	Salinity o/oo
59°50'N 01°30'W	0.28	0.38 A	36.0
53°35'N 00°30'E	1.19	2.36±0.24	30.4
53°35'N 01°50'E	-	1.95	34.6
58°58'N 02°23'E	-	0.62±0.01	30.4
53°48'N 03°00'E	-	1.95	34.0
54°07'N 04°00'E	-	1.87	32.1
54°25'N 05°00'E	-	1.79	31.0
53°43'N 06°00'E	-	1.35±0.07*	34.6
55°02'N 07°00'E	-	1.16±0.12	34.0
55°20'N 08°00'E	-	1.01	29.6

*triple determinations

Table 7.3

Caesium-137 in sea water collected at Ringhals in October 1974

Position		depth in m	^{137}Cs pCi/l	Salinity o/oo
N	E			
57°15'05"	12°06'	0	0.83±0.02	21.6
- " -	- " -	17	1.06±0.10	28.6
57°13'03"	12°03'04"	0	0.92±0.06	20.4±0.0
- " -	- " -	27	1.01±0.01	34.1±1.1
57°14'	11°53'06"	0	0.82±0.00	20.0±0.1
- " -	- " -	73-76	1.04±0.05	33.6±1.5
Mean		Surface	0.86	20.7
SD			0.06	0.8
SE			0.03	0.5
Mean		Bottom	1.04	32.1
SD			0.03	3.0
SE			0.01	1.8

and at Gyllingnæs in the Aarhus Bay (table 7.6). The DANA took samples in the North Sea and the Skagerak in February (table 7.4) and in July-August (table 7.5).

In Risø Report No. 305[1] it was suggested that the increasing ^{90}Sr and ^{137}Cs levels observed in 1973 in inner Danish waters were due to contamination from inflow of water from the North Sea contaminated with ^{137}Cs and ^{90}Sr from nuclear plants in the UK and France. The increase continued in 1974 as shown in table 7.1 and fig. 7.1, and it is now evident that the ^{137}Cs and ^{90}Sr originate from the North Sea.

The ^{90}Sr concentration has especially increased in sea water of high salinity as shown in the following regression equations:

$$\text{pCi } ^{90}\text{Sr } l^{-1} = 0.94 - 0.018 \text{ o/oo} \quad (1967\text{-}71)$$
$$\text{pCi } ^{90}\text{Sr } l^{-1} = 0.97 - 0.020 \text{ o/oo} \quad (1972)$$
$$\text{pCi } ^{90}\text{Sr } l^{-1} = 0.95 - 0.014 \text{ o/oo} \quad (1973)$$
$$\text{pCi } ^{90}\text{Sr } l^{-1} = 0.93 - 0.010 \text{ o/oo} \quad (1974)$$

(The regression analysis showed significant or probably significant regression in all cases except in 1973).

The mean salinities of sea water from the Baltic and the Norgh Sea are approx. 10 o/oo and 33 o/oo respectively[1]. From the above equation

Table 7.4

Strontium-90 and Caesium-137 in surface sea water collected in the North Sea, Skagerak and Kattegat in February 1974

Position	pCi ^{90}Sr/l	pCi ^{137}Cs/l	Salinity o/oo
58°10'N 02°21'E	0.21	0.36	34.4
57°30'N 04°00'E	0.34	0.36	34.2
53°23'N 02°45'E	1.05	1.96	32.2
57°05'N 11°41'E	0.73	1.07	21.9
53°24'N 03°18'E	0.59	0.83	34.2
57°52'N 09°41'E	0.71	1.44	34.8
56°34'N 06°52'E	0.76	1.71	34.0
59°35'N 00°47'E	0.17	0.27 A	34.4
54°24'N 04°45'E	1.05	1.91	33.8
59°13'N 01°44'E	0.24	0.13 B	34.2
55°58'N 06°21'E	-	1.27	34.2
57°33'N 08°46'E	-	1.67	34.2
55°56'N 07°50'E	-	1.30	31.5
55°19'N 07°31'E	0.69	1.33	29.8
58°46'5"N 03°38'E	-	0.71	30.4
56°13'N 04°38'E	-	2.19	34.0
Mean	0.59	1.16	32.6
SD	0.32	0.65	3.2
SE	0.10	0.16	0.8

Table 7.5

Strontium-90 and Caesium-137 in surface sea water collected in the North Sea, Skagerak and Kattegat in July-August 1974

Position	pCi ^{90}Sr/l	pCi ^{137}Cs/l	Salinity o/oo
59°50'N 01°30'W	0.26	0.34 A	[illegible]
53°35'N 00°30'E	1.19	2.36±0.24	[illegible]
53°35'N 01°50'E	-	1.95	[illegible]
58°58'N 02°23'E	-	0.62±[illegible]	[illegible]
53°48'N 03°00'E	-	1.95	[illegible]
54°07'N 04°00'E	-	1.8[illegible]	[illegible]
54°25'N 05°00'E	-	[illegible]	31.[illegible]
53°43'N 06°00'E	-	[illegible]	[illegible]
55°02'N [illegible]	-	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table 7.6

Strontium-90 and Caesium-137 in sea water collected at Gyllingnæs in April 1974

Position		depth in m	pCi $^{90}Sr/l$	pCi $^{137}Cs/l$	Salinity o/oo
N	E				
55°47'	10°08"	0	0.72	0.76	16.4
"	"	15	0.70	1.02	23.2
55°51'05"	10°17'05"	0	0.67	0.86	17.4
"	"	9	0.56	0.93	17.2

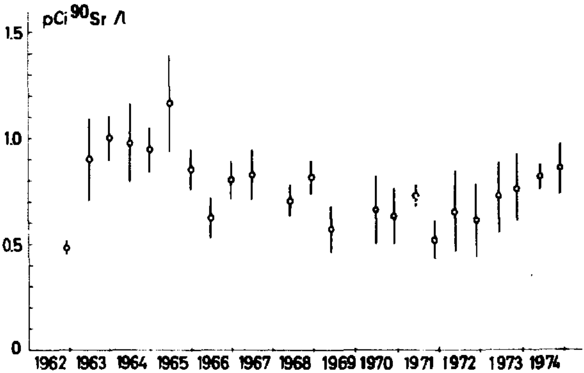

Fig. 7.1. Strontium-90 in surface sea-water from inner Danish waters, 1962-74 (1 S.D. indicated) (from table 7.1).

it is estimated that ^{90}Sr levels in sea water since 1967-71 have increased by 9% in the Baltic and by 73% in the North Sea.

The annual inflow from the North Sea through the Danish Sounds is approx. 500 km^3 water. Hence we may estimate that the inflow rate of surplus ^{90}Sr from the North Sea in 1974 was approx. 110 Ci y^{-1}. (The surplus ^{90}Sr is the ^{90}Sr from sources other than nuclear weapon fall-out. For the period 1967-71 the fall-out contribution from the inflow from the North Sea was estimated at approx. 150 Ci y^{-1} (Risø Report No. 291[1])).

In analogy with ^{90}Sr, the following regression equations were found for ^{137}Cs in inner Danish waters:

$$\text{pCi } ^{137}Cs\ l^{-1} = 0,80 - 0,0043 \text{ o/oo} \quad (1972)$$
$$\text{pCi } ^{137}Cs\ l^{-1} = 0,60 + 0,012 \text{ o/oo} \quad (1973)$$
$$\text{pCi } ^{137}Cs\ l^{-1} = 0,54 + 0,018 \text{ o/oo} \quad (1974)$$

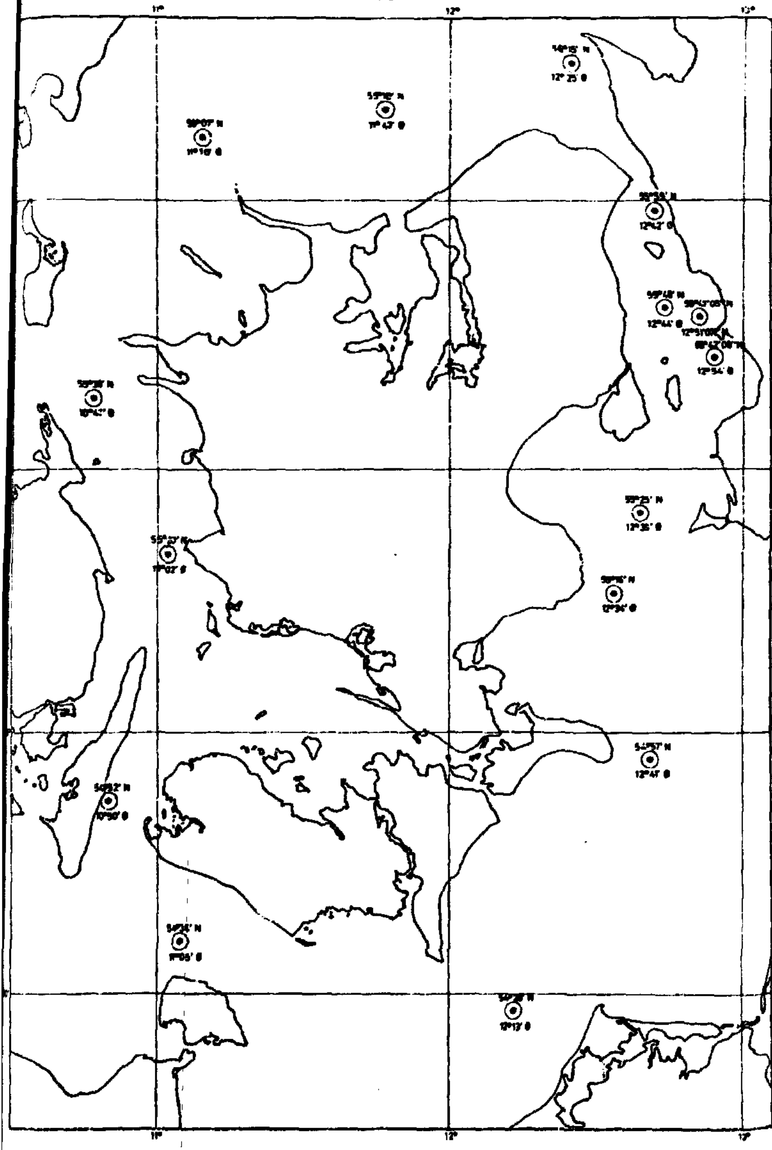

Fig. 7.2. Sea-water locations around Zealand

(The regression analysis showed a highly significant regression in 1974, probably significant in 1973, and insignificant in 1972).

There are no ^{137}Cs determinations for the years previous to 1972. Thus it is impossible to make an estimate of the fall-out ^{137}Cs level in Danish waters as for ^{90}Sr. It should be noted that the increase of ^{137}Cs from 1972

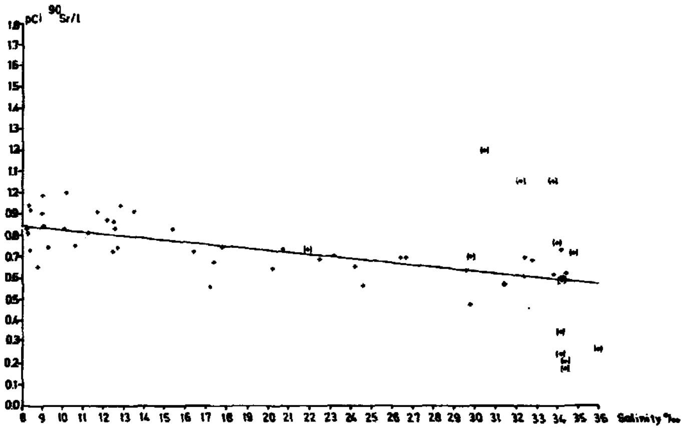

Fig. 7.3. Strontium-90 in Danish sea-water related to salinity. Regression line: pCi $^{90}Sr/l = 0.93 - 0.010$ o/oo.

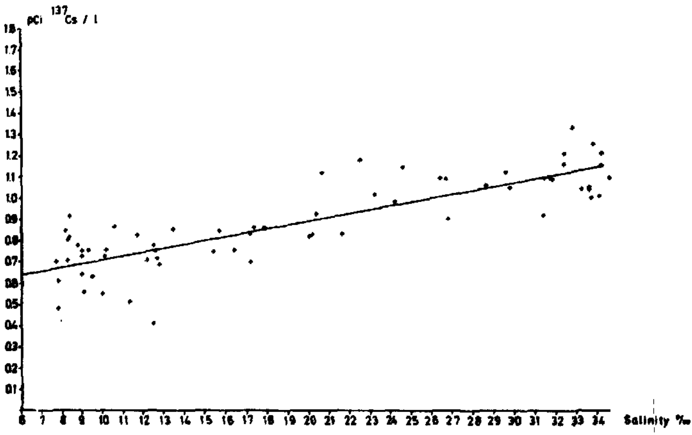

Fig. 7.4. Caesium-137 in Danish sea-water related to salinity. Regression line: pCi $^{137}Cs/l = 0.54 + 0.018$ o/oo.

to 1974 was almost nil for Baltic sea water, but 74% for water from the North Sea, i.e. comparable with the above figures for ^{90}Sr. We may, however, calculate the inflow rate of surplus ^{137}Cs from the North Sea in 1974 in the following way: the annual inflow of fall-out ^{137}Cs is estimated as $1.5 \cdot 150$ Ci = 225 Ci (1.5 is the ratio between $^{137}Cs/^{90}Sr$ in oceanic sea water according to Bowen[1]). The total inflow rate of ^{137}Cs is $2.0 \cdot (150 + 110) = 520$ Ci (2.0 is the ratio between ^{137}Cs and ^{90}Sr in North Sea

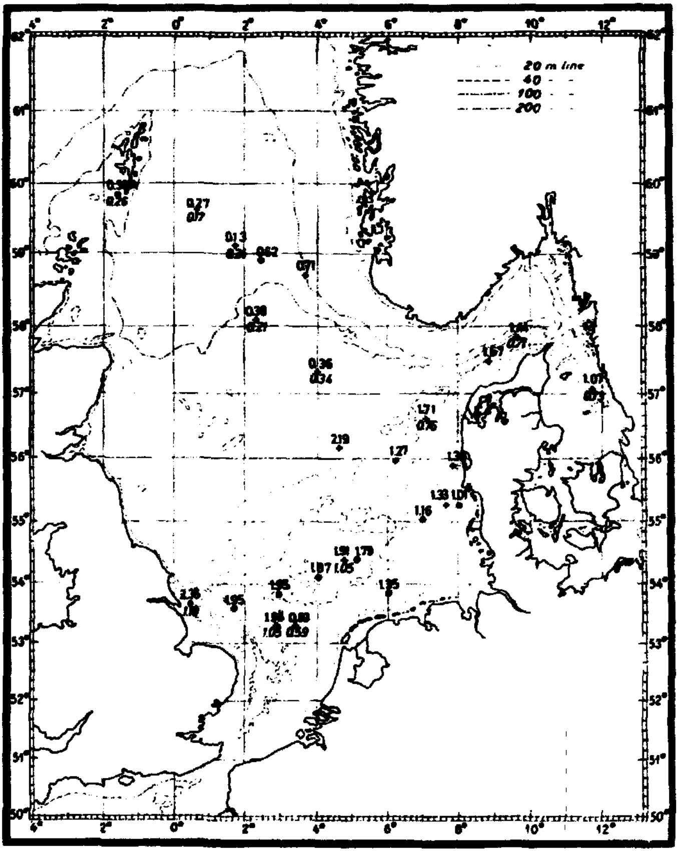

Fig. 7.9. Concentrations (pCi/l) of ^{137}Cs and ^{90}Sr (italics) in surface sea-water collected in February (+) and July-August (•) 1974.

in 1974 according to table 7.4). Hence the surplus ^{137}Cs becomes 520 - 225 = 295 Ci y^{-1}. The $^{137}Cs/^{90}Sr$ ratio in the surplus activity becomes 295/110 = 2.7, i.e. 1.8 times higher than the corresponding ratio for fall-out.

We may conclude that ^{90}Sr and especially ^{137}Cs levels are increasing in inner Danish waters. This increase is due to contamination from nuclear plants in UK and France. The increasing levels of ^{137}Cs in Danish waters mean that marine products such as fish may show increasing ^{137}Cs levels in the years to come. It furthermore implies that the procentual contribution of ^{137}Cs from fish to the total ^{137}Cs diet level may increase, because terrestrial food products are decreasing in ^{137}Cs.

8. SPECIAL SURVEYS

8.1. Meteorological Mast Experiment

As in previous years, samples of precipitation were collected from the mete rological mast at Risø at eight different heights. The ^{90}Sr analyses were only carried out on samples from the first six months.

Table 8.1.1 shows the ^{90}Sr levels in the eight bottles. The same tendency is apparent as observed earlier: the ^{90}Sr concentration increases with increasing altitude.

Table 8.1.1

Strontium-90 in rain collected at the meteorological mast in Jan.-June 1974 (sampling area 0.030 m^2)

	pCi/l	mCi/km^2	mm
2 m	1.47	0.265	180
7 m	1.65	0.299	181
23 m	1.70	0.318	187
39 m	1.88	[illegible]	196
56 m	1.66	0.320	193
72 m	1.62	0.325	200
96 m	1.98	0.317	161
123 m	2.08	0.233	112
Mean	1.76	0.306	176

The mean amount of precipitation for the first half of 1974 in the eight bottles on the mast was 176 mm, i.e. equal to the level measured in rain bottles at ground level at Risø (cf. table 3.2.4.1). The total deposition was 0.31 mCi $^{90}Sr/km^2$, i.e. 80% higher than the level measured at the ground stations at Risø (cf. 3.2.4). This observation fits the results of earlier years and can be explained by an increasing contribution of dry fall-out with increasing altitude.

8.2. Fission Product Ratios in Air Samples Collected at Different Heights in the Meteorological Mast

Table 8.2 shows the mean ratios between various fission products collected in the first half of 1974 from eight different heights of the meteorological mast. Regression analysis revealed no systematic variation with altitude for any of the ratios. The same was concluded from a similar study carried out in 1971 (cf. Risø Report No. 265[1]).

Table 8.2

Ratio between nuclides in air collected at the meteorological mast in January-June 1974

Sampling height	$^{137}Cs/^{90}Sr$	$^{144}Ce/^{137}Cs$	$^{106}Ru/^{137}Cs$	$^{95}Zr/^{137}Cs$	$^{95}Nb/^{95}Zr$	$^{95}Zr/^{144}Ce$	$^{144}Ce/^{106}Ru$
0 m	1.26	9.68	6.26	6.14	2.12	0.63	1.55
7 m	1.31	10.87	6.01	7.66	1.88	0.70	1.81
23 m	1.11	10.17	6.21	7.19	2.07	0.68	1.54
39 m	1.29	11.48	5.60	7.82	1.76	0.68	2.05
56 m	0.62	10.88	6.41	7.13	2.00	0.66	1.70
72 m	1.30	10.16	5.12	7.85	1.37	0.77	1.99
96 m	1.30	10.78	6.11	6.74	1.94	0.63	1.76
123 m	1.21	10.01	4.91	7.34	1.79	0.73	2.04
Mean	1.20	10.50	5.83	7.23	1.87	0.69	1.82

8.3. Human Milk

No human milk samples were collected in 1974.

8.4. Country-wide Measurement of the γ-Background in 1974

8.4.1. State Experimental Farms

As in previous years[1], the γ-background was measured at the State experimental farms (cf. fig. 4.1.1). Table 8.4.1.1 shows the results, and table 8.4.2 gives the analysis of variance. The variations between

Table 8.4.1.1

γ-background at the state experimental farms in 1974 (μR/h)

	Mar.	Apr.	May	Sep.	Dec.	Mean
Tylstrup	4.8	4.8	4.3	5.1	5.0	4.8
Studsgård	3.8	3.7	3.9	4.1	4.2	3.9
Ødum	6.1	5.7	5.8	5.8	5.8	5.8
Askov	5.6	4.8	5.5	5.5	5.5	5.4
St. Jyndevad	3.4	3.1	3.4	3.3	3.7	3.5
Blangstedgård	6.0	5.7	6.0	6.2	6.3	5.9
Tystofte	6.5	6.4	6.5	7.0	6.4	6.6
Virumgård	6.1	6.2	(6.1)	6.2	6.3	(6.2)
Ledreborg	6.6	6.2	(6.4)	6.5	6.7	(6.5)
Abed	6.0	5.6	5.8	6.0	5.8	5.6
Åkirkeby	(5.7)	(5.5)	5.6	(5.8)	(5.8)	(5.7)
Mean	(5.5)	(5.3)	(5.4)	(5.6)	(5.6)	(5.4)

Table 8.4.1.[illegible]

Analysis of variance of the γ-[illegible]

of the state experimental farms in 1974

(from table 8.4.1.1)

Variation	SS	f	s^2	v^2	P
Between locations	[illegible]	10	25.9[illegible]	93.26	>99.95%
Between months	[illegible]	4	[illegible]	2.28	-
L. x months	[illegible]	[illegible]	[illegible]	[illegible]	>99.[illegible]
Remainder	[illegible]	[illegible]	[illegible]		

locations was highly significant (P > 99.95%). As in previous years, it was evidently not the fall-out that determined the variation between locations. The mean level in 1974 was a little lower than the 1973 level. The level at Åkirkeby was lower than usual, but only one measurement was carried out in 1974 at this location.

Fig. 8.4 shows the γ-background since 1962 in four groups of sampling stations. The fact that stations with a low fall-out rate and a high clay content in the soil (Abed, Blangstedgård, and Tystofte) show higher γ-levels than stations with a high fall-out rate and a low clay content (but a high sand content) (Studsgård, St. Jyndevad, and Askov) was discussed in Risø Report No. 154[1].

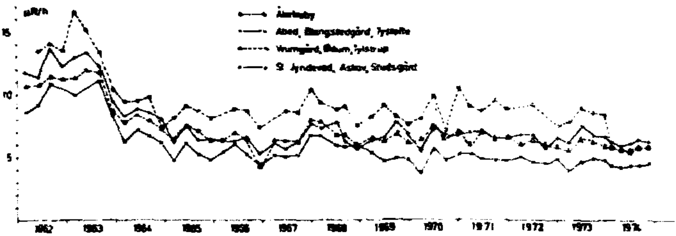

Fig. 8.4. The γ-background at the State experimental farms, 1962-74.

8.4.2. The Risø Environment

Gamma background measurements were performed in the five zones round Risø. The measurements were carried out at the locations where grass is collected (cf. figs. 3.1.2.1 and 3.1.2.2 (the coloured map)).

Tables 8.4.2.1 and 8.4.2.2 show the results.

At all locations in zone I, especially at the waste treatment station (location 3), and at location 2 in zone II, the γ-background showed increased levels because of the various radiation sources at the research establishment. The weighted annual mean for zones III-V was 6.1 µR/h. In zone I the surplus activity from the research establishment was 22.1 - 6.1 = 16.0 µR/h (in 1967: 4.0, in 1968: 3.9, in 1969: 3.3, in 1970: 4.7, in 1971: 1.6, and in 1973: 11.5 µR/h). A man working in the open in the Risø area 40 hours a week for 45 weeks a year would thus get a surplus dose of 25 mR/year.

Table 8.4.2.1

γ-background (µR/h) in zone I around Risø in 1974

Location	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1	6.7	6.2	6.7	6.7	7.0	18.0	7.7	[illegible]	8.0	8.7	6.7	8.1
2	9.4	9.9	9.9	9.4	10.4	11.2	10.2	[illegible]	9.9	11.7	8.7	9.8
3	62.9	56.6	46.9	54.3	66.6	65.3	70.4	68.2	64.5	55.7	59.4	61.3
4	9.7	9.2	9.4	13.6	17.9	9.9	9.0	9.3	9.0	9.9	9.0	10.0
5	20.0	21.3	19.6	20.8	19.3	21.7	17.6	24.4	17.6	28.4	17.1	20.6
Mean	21.7	22.4	18.3	21.0	23.2	25.7	23.0	23.4	21.8	22.9	20.0	22.1

Table 8.4.2.2

γ-background (μR/h) in four zones (II-V) around Risø in 1974

Risø zone (cf. coloured map)	Location	Feb.	Mar.	Apr.	May	July	Aug.	Sept.	Mean
II	1		6.0	6.0	6.0	6.7		6.2	6.2
-	2		7.2	6.7	6.7	8.0		5.7	7.1
-	3		5.7	5.7	5.7	6.0		5.5	5.7*
-	4		6.0	6.0	6.0	7.0		7.0	6.4
Mean			6.2	6.1	6.1	6.9		6.4	6.3
III	1		6.7	6.5	6.5	7.2		7.0	6.8
-	2		6.5	6.5	6.5	7.0		6.0	6.5
-	3		6.5	6.2	6.2	7.2		6.7	6.6
-	4		5.7	6.0	6.0	7.5		5.8	6.2
Mean			6.4	6.3	6.3	7.2		6.4	6.5
IV	1	6.0		6.0	6.2		5.8		6.0
-	2	6.5		6.5	6.5		7.0		6.6
-	3	6.7		5.5	5.7		7.0		6.2
-	4	5.5		5.7	5.7		6.5		5.9
-	5	6.0		6.0	5.7		5.8		5.9
-	6	5.7		5.7	5.5		5.8		5.7
-	7	5.7		5.7	5.7		6.2		5.8
-	8	6.0		5.7	5.7		5.3		5.7
Mean		6.0		5.9	5.8		6.2		6.0
V	1	6.0		5.2	6.0		6.0		5.8
-	2	5.7		6.5	6.5		6.2		6.2
-	3	6.0		6.5	6.5		6.7		6.4
-	4	5.7		5.7	5.7		6.0		5.8
-	5	5.5		6.2	6.2		7.0		6.2
-	6	6.0		5.7	6.0		6.5		6.1
-	7	6.0		6.7	6.5		5.8		6.3
-	8	6.5		6.5	6.5		6.2		6.4
-	9	6.2		6.7	6.5		6.7		6.5
-	10	5.2		5.5	5.7		4.8		5.3
-	11	6.2		6.2	6.2		6.0		6.2
-	12	6.0		6.2	6.2		6.0		6.1
Mean		5.9		6.1	6.2		6.2		6.1

8.4.3. A Location in Zealand

As it is important to have knowledge of the preoperational radiation levels before a nuclear power plant goes critical, it was in 1967 decided to initiate such measurements at one location in Zealand (and one in Jutland) that may be used for nuclear power plants in the future.

Table 8.4.3

γ-background (μR/h) around a location in Zealand in 1974

Zone and sector	Apr.
A 2	5.0
A 3	4.8
A 4	7.5
A 5	6.0
A 6	6.2
A 7	6.7
A 8	6.0
A 9	5.5
Mean	6.0
B 1	5.0
B 2	6.2
B 3	6.2
B 4	5.2
B 5	6.5
B 6	6.7
B 7	5.2
B 8	5.7
B 9	6.2
B 10	6.5
Mean	5.9

Zone and sector	Apr.
C 1	4.3
C 2	5.0
C 3	5.2
C 4	5.5
C 5	5.2
C 6	5.7
C 7	6.5
C 8	6.5
C 9	6.2
C 10	6.7
C 11	6.7
C 12	5.2
Mean	5.7
D 1	6.5
D 2	5.5
D 3	5.2
D 4	5.7
D 5	5.7
D 6	6.5
D 7	6.2
D 8	6.7
D 9	5.0
D 10	5.5
D 11	6.0
D 12	4.5
Mean	5.8

The area around the location was divided into four zones: A, B, C, and D, with radii of 5, 10, 15, and 20 km respectively. The zones were each divided into 12 30° sectors, sector 1 being from due north and 30° clockwise, sector 2 from 30 to 60°, and so on. A measuring location was thus determined by a zone letter and a sector number. Locations in the sea were omitted.

Table 8.4.3 shows the results. The mean for all locations was 5.8 μR/h, i.e. a little lower than the level found in zones III-V around Risø.

8.4.4. A Location in Jutland

Table 8.4.4 shows a similar investigation as in 8.4.3 for a location in Jutland. The annual mean for all locations was 5.5 μR/h, i.e. a little lower than the levels for Zealand (cf. 8.4.2 and 8.4.3).

Table 8.4.4

γ-background (μR/h) around a location in Jutland in 1974

Zone and sector	Apr.	Zone and sector	Apr.
A 1	5.5	C 1	6.0
A 2	6.0	C 2	7.0
A 3	6.2	C 3	3.5
A 4	4.3	C 4	6.2
A 5	5.0	C 5	6.2
A 6	4.5	C 6	5.0
A 7	5.2	C 7	6.0
A 8	3.8	C 8	5.5
A 9	5.0	C 9	4.8
A 10	5.5	C 10	4.5
A 11	5.7	C 11	4.8
A 12	5.5	C 12	5.7
Mean	5.2	Mean	5.4
B 1	5.7	D 1	5.7
B 2	6.5	D 2	6.2
B 3	4.3	D 3	6.0
B 4	7.0	D 4	6.0
B 5	5.7	D 5	5.2
B 6	5.7	D 6	5.2
B 7	5.5	D 7	5.2
B 8	5.7	D 8	5.7
B 9	5.5	D 9	4.5
B 10	5.5	D 10	5.5
B 11	6.7	D 11	5.5
B 12	6.2	D 12	5.0
Mean	5.8	Mean	5.5

8.4.5. The Coasts of the Great Belt

The Great Belt is a main shipping route for international traffic through inner Danish Waters. Occasionally this waterway will be passed by nuclear ships and an environmental γ-survey of its coastline was therefore performed. Table 8.4.5 shows the results. The levels were generally a little lower than those found in most of the other areas of the country. The annual mean was 5.6 μR/h.

Table 8.4.5

The γ-background (μR/h) along the coasts of the Great Belt in 1974

Location	April
Agersø	3.8
Omø	3.8
Røsnæs	3.8
Reersø	5.5
Halskov	6.5
Knudshoved	4.8
Risinge	8.2
Fyns Hoved	5.7
Tårup Strand	5.5
Langeland N.	5.7
Tranekær	5.7
Vindeby Strand	7.5
Kelds Nor	6.0
Mean	5.6

8.4.6. General Remarks

The γ-background in 1974 was on the average 90% of the γ-background in 1973. We have no explanation for this decrease, but we suspect it to be due to the calibration of the NaI-crystal.

8.5. Preoperational Environmental Surveys at Barsebäck, Ringhals and Gyllingnæs

Sweden is constructing nuclear power plants facing the Sound at Barsebäck and the Cattegat at Ringhals. Ringhals started up in 1974 and Barsebäck became critical in 1975. As both sites are close to Danish waters and fishing grounds, various marine samples are collected from these areas.

Table 8.5.1.1. Sea water analysis of Barsebäck samples are shown in table 7.2.

Table 8.5.1.2

Caesium-137 in bed soil collected at Barsebäck in November 1974 (HAPS[18] sampler: area 145 cm^2) (cf. Risø Report No. 305, 3.4[1])

Location	Depth	pCi/kg	mCi/km^2
55°45'9"N 12°56'4"E	0-3 cm	846	7.2
-	4-6 cm	693	5.9
-	7-9 cm	570	4.6
-	10-12 cm	272	2.6
-	13-15 cm	155	1.4
-	16-18 cm	103	0.8
Weighted mean	0-18 cm	439	Σ 22.5
55°46'2"N 12°53'2"E	16-18 cm	44	0.9
-	19-20 cm	0	0

Table 8.5.1.3. Fish: no analysis.

Table 8.5.1.4. Sea plants: no analysis.

Table 8.5.1.5. Bottom animals: 1 sea urchin 31 M.U. and 65 pCi ^{137}Cs/kg collected in 1971.

Table 8.5.2.1. Sea water analysis of Ringhals samples are shown in table 7.3.

Table 8.5.2.2

Caesium-137 in bed soil collected at Ringhals (HAPS[18] sampler: area 145 cm^2)

Location	Date	Depth	pCi/kg	mCi/km^2
57°15'1"N 12°08'E	23/10-74	0-3 cm	31	
57°17'1"N 12°07'2"E	23/10-74	0-3 cm	26	
57°17'1"N 12°07'2"E	23/10-74	0-3 cm	81	3.2
57°15'1"N 12°03'7"E	23/10-74	0-3 cm	230	8.4
57°15'1"N 12°03'7"E	23/10-74	4-6 cm	164	6.0
57°15'1"N 12°03'7"E	22/10-74	7-8.5 cm	42	1.4
57°13'3"N 12°03'4"E	23/10-74	0-3 cm	260	8.6

Only a few samples were analysed, but all samples are being retained for comparison with samples to be collected when the plants are in full operation. The results of the samples analysed so far are given beneath in tables 8.5.1 and 8.5.2. The analysis of the sea water samples is shown in tables 7.2 and 7.3.

Furthermore, a few preliminary samples were collected at Gyllingnæs, the possible location of a future Danish nuclear power plant. The results of the analysis are shown in table 8.5.3 and for the sea water in table 7.6.

Table 8.5.2.3

Caesium-137 in fish collected at Ringhals

	Location	Date	pCi/kg	M.U.
Dab	N.W. Ringhals	27/9-73	28.6	7.8
Whiting	N.W. Ringhals	27/9-73	4.6	5.0
Dab	N.W. Ringhals	27/9-73	45.6	13.8
Dab	Fladengrund	27/9-73	32.3	8.8
Dab	N.W. Ringhals	27/9-73	32.8	8.8
Mean		1973	28.8	8.8
Dab	W. Ringhals	27/9-74	27.9	8.1
Whiting	W. Ringhals	27/9-74	28.8	7.5
Dab	W. Ringhals	27/9-74	23.6	8.6
Mean		1974	26.8	8.1

Table 8.5.2.4

Caesium-137 in sea plants collected at Ringhals in October 1974

Location	pCi ^{137}Cs/g ash	M.U.
I	0.42	7.0
II	0.36	13.0
Mean	0.39	10.0

Table 8.5.2.5. Bottom animals: no analysis.

Table 8.5.3.1. Analysis of sea water samples collected at Gyllingnæs are shown in table 7.6.

Table 8.5.3.2. No analysis of bed soil samples from Gyllingnæs.

Table 8.5.3.3

Caesium-137 in fish collected at Gyllingnæs in 1974

	Date	^{137}Cs pCi/kg	M.U.
Dab	21/4	36.0	10.5
Dab	24/4	29.6	9.5
Mean		32.8	10.0

Table 8.5.3.4

Caesium-137 in sea plants collected at Gyllingnæs in 1974

	Date	pCi ^{137}Cs/g ash	M.U.
Seaweed	21/4	0.74	3.0
Seaweed	21/4	0.72	2.5
Seaweed	24/4	0.43	8.0
Bladder wrack	23/4	0.69	6.0
Bladder wrack	23/4	0.59	6.2
Mean		0.63	5.1

Table 8.5.3.5

Caesium-137 in bottom animals collected at Gyllingnæs in 1974

Location	Species	pCi ^{137}Cs/kg	pCi ^{137}Cs/g ash	M.U.
Gyllingnæs	Starfish	17.2		5.8
55°47'N 10°08'E (13 m)	Starfish	18.4		5.7
Mean		17.8		5.75
N.E. Kalvsnakke	Common mussel shells		0	0
S.W. Kalvsnakke	Common mussel shells		0	0
Mean			0	0
N.E. Kalvsnakke	Common mussel flesh		0	0
S.W. Kalvsnakke	Common mussel flesh		0.003 A	0.08 A
S.W. Kalvsnakke	Common mussel flesh		0.25	11.7
Mean			0.08	3.9

8.6. Strontium-90 and Caesium-137 in Samples of Beets Collected since 1963

Beet is an important component of the diet of Danish cows. Approximately one third of the feed units in the fodder originates from beets and beet-offal. In comparison grass provides one half of the feed units in the total fodder[20]. In 1964 (Risø Report No. 107)[1] samples of fodder were collected from various locations especially in eastern Denmark but since then there has been no information on the levels in cattle fodder. The State experimental farms at Askov and Ledreborg provided us with old samples of dried beet material (roots and tops) covering the period since 1963. Tables 8.6.1 and 8.6.2 show the results of the ^{90}Sr and ^{137}Cs determinations.

In appendix E we have estimated the data from the years where there are no samples. The VAR-3[12] method is used for the estimation where cabbage and kale, potatoes and carrots are used for leaves and roots respectively.

Table 8.6.1

Strontium-90 in beets and beets leaves in 1963-1972

Years	Species	Studsgård		Askov		Ledreborg	
		pCi/g dry	S.U.	pCi/g dry	S.U.	pCi/g dry	S.U.
1963	Beet leaves			1.86	162		
	Beet			0.48	193		
1964	Beet leaves			0.94	74		
	Beet			0.32	93		
	Swede leaves			1.37	88		
	Swede			0.35	53		
1965	Beet leaves			0.88	66		
	Beet			0.48	186		
	Swede leaves	1.11	111	0.64	114		
	Swede	0.33	89	0.84	83		
1966	Beet leaves	0.81	60	0.64	51		
	Beet	0.29	122				
	Swede			0.47±0.15	150±14		
1968	Beet						66
1970	Beet						87
1972	Beet						44

Table 8.6.2

Caesium-137 in beets and beets leaves in 1963-1972

Years	Species	Studsgård		Askov		Ledreborg	
		pCi/g dry	M.U.	pCi/g dry	M.U.	pCi/g dry	M.U.
1963	Beet leaves			2.99	89		
	Beet			0.46	18		
1964	Beet leaves			1.32	39		
	Beet			0.19 A	8 A		
	Swede leaves			1.15	57		
	Swede			0.30	19		
1965	Beet leaves			0.75	13		
	Beet			0	0		
	Swede leaves	0.42	20	0.52	37		
	Swede	0.13 B	7 B	0.23 A	10 A		
1966	Beet leaves	0.28	7	0.26 A	7 A		
	Beet	0.24 A	15 A				
	Swede			0.03±0.03B	1.5±1.5B		
1968	Beet						1.1 A
1970	Beet						0.7 B
1972	Beet						0

9. CONCLUSION

9.1. Risø Environmental Monitoring

No radioactive contamination of the environment originating from the operation of the research establishment was ascertained outside Risø in 1974. As in previous years, the variations in contamination level were independent of the distance of the sampling locations from Risø.

9.2. Nuclear-Weapon Debris in Air, Precipitation, Soil, Ground Water, and Surface Water

The mean content of ^{90}Sr in air collected in 1974 was 0.0014 pCi $^{90}Sr/m^3$, i.e. 3.6 times the 1973 level. The average fall-out at the State experimental farms in 1974 was 0.71 mCi $^{90}Sr/km^2$ or 3.7 times the 1973 figure, and the mean concentration of ^{90}Sr in rain water was 0.98 pCi $^{90}Sr/l$.

By the end of 1974 the accumulated fall-out down to a depth of 50 cm was approx. 56 mCi $^{90}Sr/km^2$. The corresponding ^{137}Cs was measured at 94 mCi/km^2.

In agreement with the greater precipitation in that part of the country, fall-out levels in Jutland were 15-25% higher than levels found in eastern Denmark.

The median level of ^{90}Sr in Danish ground water was 0.006 pCi $^{90}Sr/l$.

9.3. Strontium-90 and Caesium-137 in the Human Diet

The mean level of ^{90}Sr in Danish milk was 4.5 S.U., and the mean content of ^{137}Cs was approx. 7.3 pCi $^{137}Cs/l$.

The 1974 ^{90}Sr levels were nearly equal to the levels found in milk produced in 1973, while the ^{137}Cs levels had increased a little.

The ^{90}Sr mean content in grain from the 1974 harvest was 33 pCi $^{90}Sr/kg$. The ^{137}Cs mean content in grain was 37 pCi $^{137}Cs/kg$. The ^{90}Sr level in grain from the 1974 harvest was 1.3 times the level found in the 1973 harvest, and ^{137}Cs was 3.7 times the 1973 level.

The mean contents of ^{90}Sr and ^{137}Cs in Danish vegetables collected in 1974 were 10 pCi $^{90}Sr/kg$ (28 S.U.) and 1.9 pCi $^{137}Cs/kg$ respectively, and in fruits 3.0 pCi $^{90}Sr/kg$ and 4.7 pCi $^{137}Cs/kg$; potatoes contained 3.2 pCi $^{90}Sr/kg$ and 6 pCi $^{137}Cs/kg$.

The mean levels of ^{90}Sr and ^{137}Cs in total-diet samples collected in 1974 were 7.1 S.U., or 12.0 pCi $^{90}Sr/day$ and 19 pCi $^{137}Cs/day$ respectively. From analyses of the individual diet components, the ^{90}Sr level in the Danish average diet was estimated to be 5.7 S.U. and the ^{137}Cs intake to be 15 pCi $^{137}Cs/day$. The ^{90}Sr and ^{137}Cs levels in the Danish total diet consumed in 1974 were nearly equal to the 1973 levels.

Grain products contributed 31% and milk products 35% to the total ^{90}Sr intake; 28% of the ^{137}Cs in the diet originated from meat, 18% from grain products, and 22% from milk products.

Both ^{90}Sr and ^{137}Cs diet levels were on the average significantly higher in Jutland than in eastern Denmark.

9.4. Strontium-90 and Caesium-137 in Humans

The ^{90}Sr mean content in human bone (vertebrae) collected in 1974 was 1.3 S.U. in new-born children, 1.8 S.U. in infants, 1.4 S.U. in children and teenagers, 1.3 S.U. in adults (20-29 years old), and 1.5 S.U. in adults of more than 29 years. The 1974 bone levels were generally a little lower than the 1973 levels.

The mean content of ^{137}Cs in the human body in 1974 was estimated from whole-body countings to be 1.3 nCi (10 pCi $^{137}Cs/g$ K), i.e. a little lower than the 1973 level.

9.5. Strontium-90 in Sea Water

The mean content of ^{90}Sr in inner Danish surface waters was approx. 0.83 pCi $^{90}Sr/l$ in 1974, i.e. higher than the levels in previous years. The ^{137}Cs levels in Danish waters are also increasing due to the inflow of contaminated water from the North Sea.

9.6. The γ-Background

The average γ-background measured with a NaI crystal at the State experimental farms in 1974 was 5.4 μR/h.

9.7. Summary

The Chinese thermonuclear atmospheric tests on June 27, 1973, were responsible for the 3-4 times greater fall-out rate in 1974 as compared with 1973. All levels that mainly depend upon the activity in the atmosphere have consequently shown a marked increase in 1974.

The concentrations of long-lived fall-out nuclides in ground-level air and precipitation collected in 1974 were 3.6 times the levels found in 1973.

In milk produced in 1974 the ^{137}Cs levels were 1.2 times higher than the 1973 levels. In grain from 1973 the ^{137}Cs levels were 3.7 times those found in 1973.

The ^{90}Sr and ^{137}Cs levels in the total diet consumed in 1974 were nearly unchanged as compared with the 1973 levels.

The ^{90}Sr concentrations in human bone were a little lower in 1974 than in 1973.

Sea water in inner Danish waters showed increasing ^{90}Sr and ^{137}Cs levels due to pollution from reprocessing plants in the UK and in France.

APPENDIX A

Calculated Fall-out in the Eight Zones in 1974

Zone	mm precipitation in 1974	mCi $^{90}Sr/km^2$ in 1974	Accumulated mCi $^{90}Sr/km^2$ by the end of 1974 (0-50 cm)
I: N. Jutland II: E. Jutland III: W. Jutland IV: S. Jutland	761	0.73	61
V: Fumen VI: Zealand VII: Lolland-Falster	656	0.667	48
VIII: Bornholm	643	0.630	45
Area-weighted mean	728	0.710	57

The amounts of precipitation were obtained from ref. 9, and from 4.1 and 4.2.

APPENDIX B

Statistical information

Zone	Area in km^2 15) 1971	Population in thousands 16) 1971	Annual milk production in mega-kg 14) 1971	Annual wheat production in mega-kg 13) 1972	Annual rye production in mega-kg 13) 1972	Annual potato production in mega-kg 13) 1972	Vegetable area in km^2 13) 1972
I: N. Jutland	6,171	457	811	145	155	609	14
II: E. Jutland	7,561	841	1,258				
III: W. Jutland	12,104	561	926				
IV: S. Jutland	3,929	229	672				
V: Funen	3,486	434	382	448	71	100	73
VI: Zealand	7,435	2,146*	395				
VII: Lolland-Falster	1,795	126	60				
VIII: Bornholm	588	47	29				
Total	43,069	4,950	4,562	593	226	709	87

* 1,346,000 people were living in Greater Copenhagen and 801,000 in the remaining part of Zealand.

APPENDIX C

We have revised our prediction models for diet components and total diet. For milk we used our data[1] from 1962-74, for grain: 1959-74 (^{137}Cs: 1962-74), and for total diet: 1961-74. The terms in the models were similar to those used in previous years (cf. Risø Report No. 305, Appendix C[1]), but for ^{90}Sr we divided the term for accumulated fall-out (A_i) into two terms, one with an effective half-life of ^{90}Sr of 5 years and one with a 28-year half-life.

This has in general improved the models. In a few cases, however, one of the two A_i terms became negative. The model was then altered to one A_i term and tested for half-lives of 5, 10, 15, 20, 25 and 28 years. We then chose the half-life giving the best fit.

In Appendix D values are shown for the fall-out rates (d_i) and the accumulated fall-out (A_i) used in our calculations of prediction models.

In tables C 1 and C 2 we have also calculated the infinite exposure integral (IEI) for the diet components and the total diet. IEI is equal to the equilibrium level in the diet for a constant annual fall-out rate of 1 mCi $^{90}Sr/km^2$, or to the UNSCEAR[21] transfer coefficient P_{23}. In the case of ^{137}Cs the prediction models are given for d_i and A_i values of ^{90}Sr as also the IEI values.

It is remarkable that, with the exception of ^{90}Sr in total diet, Jutland in all cases shows higher IEI values than the Islands. The reason why the total diet differs from the general pattern is probably due to a transfer of foods (e.g. milk) from Jutland to the Islands in recent years. This has made the total diet levels in the Islands decrease more slowly than the levels in Jutland. This again has resulted in an overestimation of the coefficients for the A_i terms in the prediction model for the Islands.

Table C 1

A comparison between observed and predicted ^{90}Sr levels in the human food chain in Denmark in 1974

Sample and area	Observed	Predicted	Equation used for the prediction	I.E.I.
Milk from Jutland	5.5	5.4	$S.U_i = 1.00\ d_i + 0.73 d_{i-1} + 0.22\ A_{i-2(5)}$	(3.3)
Milk from the Islands	3.3	3.4	$S.U_i = 0.75\ d_i + 0.66\ d_{i-1} + 0.12\ A_{i-2(5)} + 0.019\ A_{i-2(28)}$	(3.0)
Rye from Jutland	119	94	$S.U_i = 222\ d_i + 0.48\ A_{i-1(5)} + 0.61\ A_{i-1(28)}$	(65)
Rye from the Islands	65	56	$S.U_i = 170\ d_i + 0.59\ A_{i-1(28)}$	(52)
Barley from Jutland	86	77	$S.U_i = 164\ d_i + 1.90\ A_{i-1(5)} + 0.10\ A_{i-1(28)}$	(45)
Barley from the Islands	39	37	$S.U_i = 98\ d_i + 0.83\ A_{i-1(5)} + 0.18\ A_{i-1(28)}$	(30)
Wheat from Jutland	99	103	$S.U_i = 164\ d_i + 1.65\ A_{i-1(5)} + 0.60\ A_{i-1(28)}$	(63)
Wheat from the Islands	63	57	$S.U_i = 138\ d_i + 0.33\ A_{i-1(5)} + 0.62\ A_{i-1(28)}$	(50)
Oats from Jutland	64	72	$S.U_i = 73.5\ d_i + 0.93\ A_{i-1(28)}$	(50)
Oats from the Islands	33	35	$S.U_i = 59.0\ d_i + 0.54\ A_{i-1(28)}$	(32)
Total diet from Jutland	8.7	6.7	$S.U_i = 0.79\ d_i + 1.61\ d_{i-1} + 0.10\ A_{i-2(5)} + 0.062\ A_{i-2(28)}$	(5.6)
Total diet from the Islands	6.1	5.4	$S.U_i = 0.75\ d_i + 1.58\ d_{i-1} + 0.022 A_{i-2(5)} + 0.089\ A_{i-2(28)}$	(6.1)

Table C 2

A comparison between observed and predicted ^{137}Cs levels
in the human food chain in Denmark in 1974

Sample and area	Observed	Predicted	Equation used for the prediction	|E|
Milk from Jutland	5.7	6.3	$M.U_i = 4.35\ d_i + 1.56\ d_{i-1} + 0.23\ d_{i-2} + 0.040\ A_{i-3(30)}$	(7.9)
Milk from the Islands	2.7	3.0	$M.U_i = 2.54\ d_i + 1.55\ d_{i-1} + 0.023\ A_{i-2(30)}$	(5.1)
Rye from Jutland	64	61	$pCi\ ^{137}Cs\ kg^{-1} = 131\ d_{i(May-Aug.)}$	33
Rye from the Islands	34	47	$pCi\ ^{137}Cs\ kg^{-1} = 125\ d_{i(May-Aug.)}$	31
Barley from Jutland	33	47	$pCi\ ^{137}Cs\ kg^{-1} = 101\ d_{i(May-Aug.)}$	25
Barley from the Islands	26	32	$pCi\ ^{137}Cs\ kg^{-1} = 84\ d_{i(May-Aug.)}$	21
Wheat from Jutland	35	43	$pCi\ ^{137}Cs\ kg^{-1} = 94\ d_{i(May-Aug.)}$	24
Wheat from the Islands	27	27	$pCi\ ^{137}Cs\ kg^{-1} = 72\ d_{i(May-Aug.)}$	18
Oats from Jutland	43	38	$pCi\ ^{137}Cs\ kg^{-1} = 83\ d_{i(May-Aug.)}$	21
Oats from the Islands	33	29	$pCi\ ^{137}Cs\ kg^{-1} = 78\ d_{i(May-Aug.)}$	20
Total diet from Jutland	5.5	4.0	$M.U_i = 3.79\ d_i + 1.58\ (d_{i-1} + d_{i-2})$	(7.0)
Total diet from the Islands	3.3	3.1	$M.U_i = 3.49\ d_i + 1.48\ (d_{i-1} + d_{i-2})$	(6.5)

APPENDIX D

<u>di</u>: Annual fall-out rate in mCi $^{90}Sr\ km^{-2}y^{-1}$.

<u>$Ai_{(5)}$</u>: Accumulated fall-out by the end of the year (i) assuming an effective halflife of ^{90}Sr of 5 y.
Unit: mCi $^{90}Sr\ km^{-2}$.

<u>$Ai_{(15)}$ & $Ai_{(27.7)}$</u>: Accumulated fall-out by the end of the year (i) assuming effective halflives of ^{90}Sr of 15 y and 27.7 y respectively.
Unit: mCi $^{90}Sr\ km^{-2}$.

<u>$di_{(May-Aug.)}$ & $di_{(July-Aug.)}$</u>: The fall-out rates in the periods: May-Aug. and July-Aug. respectively.
Unit: mCi $^{90}Sr\ km^{-2}\ period^{-1}$.

The fall-out rate (di) was based on the Danish country wide collected precipitation data for the period 1962-74 (cf. table 4.11[1]). Before 1962 the levels in the tables have been estimated from the HASL data for New York (HASL Appendix 291, 1975) considering that the mean ratio between ^{90}Sr fall-out in Denmark and New York has been 0.7 in the period 1962-74.

The $di_{(May-Aug.)}$ and $di_{(July-Aug.)}$ values were also obtained from table 4.1.1[1] for the period 1962-74. For the years 1959-61 the values were calculated from data obtained from ^{90}Sr analysis on air (1959) and precipitation samples (1962 & 61) collected at Risø (cf. Ref. 17) and before 1959 the values were estimated from the corresponding di values assuming that the ratios $di_{(May-Aug.)}/di$ and $di_{(July-Aug.)}/di$ were constant in time and equal to the means found for the period 1962-74 which were 0.54 (1 S.D.:0.09) and 0.24 (1 S.D.:0.06) respectively.

APPENDIX [illegible]

Fall-out rates and accumulated fall-o[illegible] ($^{90}Sr/km^2$) in Denmark 1950-1974

	Denmark				Jutland				Islands				Denmark*		Jutland		Islands	
	di	$Ai_{(5)}$	$Ai_{(15)}$	$Ai_{(27.7)}$	di	$Ai_{(5)}$	$Ai_{(15)}$	$Ai_{(27.7)}$	di	$Ai_{(5)}$	$Ai_{(15)}$	$Ai_{(27.7)}$	$di_{(May-Aug.)}$	$di_{(July-Aug.)}$	$di_{(May-Aug.)}$	$di_{(July-Aug.)}$	$di_{(May-Aug.)}$	$di_{(July-Aug.)}$
50	0.021	0.018	0.020	0.020	0.022	0.019	0.021	0.021	0.020	0.017	0.019	0.020	0.01	0.01	0.01	0.01	0.01	0.01
51	0.101	0.104	0.116	0.118	0.114	0.116	0.129	0.132	0.088	0.092	0.107	0.105	0.05	0.02	0.06	0.03	0.05	0.02
52	0.198	0.263	0.299	0.309	0.224	0.296	0.337	0.347	0.172	0.230	0.262	0.270	0.11	0.05	0.12	0.05	0.09	0.04
53	0.500	0.664	0.763	0.789	0.566	0.751	0.862	0.891	0.434	0.578	0.665	0.687	0.27	0.12	0.31	0.14	0.23	0.10
54	1.901	2.233	2.544	2.623	2.152	2.526	2.878	2.967	1.659	1.939	2.210	2.279	1.03	0.46	1.16	0.52	0.89	0.40
55	2.501	4.121	4.817	4.997	2.831	4.664	5.451	5.655	2.171	3.578	4.183	4.340	1.35	0.60	1.53	0.68	1.17	0.52
56	3.101	6.287	7.560	7.898	3.510	7.116	8.557	8.939	2.692	5.458	6.564	6.858	1.67	0.74	1.90	0.84	1.45	0.65
57	3.101	8.173	10.180	10.728	3.510	9.251	11.522	12.142	2.692	7.095	8.839	9.313	1.67	0.74	1.90	0.84	1.45	0.65
58	4.302	10.860	13.828	14.658	4.869	12.292	15.651	16.591	3.734	9.427	12.004	12.725	2.32	1.03	2.63	1.17	2.02	0.90
59	6.102	14.766	19.030	20.247	6.908	16.715	21.540	22.918	5.297	12.817	16.519	17.576	2.50	0.68	2.76	0.75	2.24	0.61
60	1.140	13.847	19.259	20.859	1.291	15.675	21.800	23.610	0.990	12.020	16.718	18.107	0.47	0.31	0.52	0.34	0.42	0.28
61	1.481	13.344	19.803	21.787	1.676	15.105	22.416	24.661	1.285	11.583	17.190	18.913	0.66	0.47	0.73	0.52	0.59	0.42
62	7.428	18.063	26.001	28.493	7.976	20.093	29.019	31.830	6.880	16.073	22.983	25.155	4.223	1.057	4.566	2.052	3.880	1.662
63	16.695	30.276	40.768	44.071	18.453	33.556	45.329	49.041	14.937	26.996	36.208	39.101	9.965	5.629	10.753	5.932	9.177	5.327
64	10.412	35.421	48.869	53.136	11.685	39.384	54.439	59.225	9.139	31.457	43.299	47.048	6.235	2.568	7.170	2.910	5.299	2.226
65	3.954	34.277	50.437	55.679	4.204	37.946	55.994	61.861	3.704	30.609	44.880	49.477	2.029	0.850	2.094	0.852	1.964	0.848
66	2.145	31.707	50.207	56.395	2.166	34.919	55.534	62.445	2.124	28.495	44.881	50.345	1.049	0.418	0.984	0.496	1.114	0.340
67	1.047	28.514	48.940	56.023	1.176	31.422	54.149	62.048	0.918	25.606	43.731	49.997	0.367	0.141	0.380	0.134	0.354	0.148
68	1.402	26.044	48.069	56.006	1.568	28.720	53.201	62.045	1.237	23.368	42.938	49.968	0.848	0.426	0.910	0.460	0.786	0.392
69	1.035	23.574	46.887	55.632	1.241	26.083	51.983	61.721	0.829	21.065	41.791	49.542	0.614	0.278	0.723	0.319	0.505	0.233
70	1.647	21.956	46.342	55.863	1.993	24.442	51.539	62.140	1.301	19.471	41.146	49.586	0.908	0.547	1.076	0.632	0.740	0.462
71	1.506	20.425	45.608	55.951	1.726	22.780	50.860	62.288	1.286	18.070	40.515	49.615	0.992	0.406	1.154	0.516	0.830	0.294
72	0.435	18.160	44.040	54.993	0.457	20.229	49.000	61.194	0.413	16.090	39.080	48.792	0.253	0.084	0.262	0.064	0.244	0.084
73	0.187	15.976	42.235	53.821	0.215	18.549	46.993	59.891	0.160	14.153	37.476	47.750	0.075	0.033	0.093	0.039	0.057	0.027
74	0.710	14.526	41.008	53.183	0.779	17.697	45.616	59.171	0.643	12.881	36.398	47.197	0.421	0.190	0.463	0.219	0.378	0.162

APPENDIX E

Estimates of ^{90}Sr and ^{137}Cs Levels in Beets and Swedes Grown in Denmark since 1959

The aim is to estimate the pCi $^{90}Sr/g$ Ca and pCi $^{137}Cs/g$ K levels in beets and swedes, which are important constituents of cattle fodder in Denmark and consequently influence the ^{90}Sr and ^{137}Cs concentrations in milk.

As shown in 8.6, the number of measured results of beet and swede samples is rather sparse. However, by means of the VAR-3[12] method we are able to estimate the missing figures. The VAR-3 method implies that anovas are carried out on the observed beet and swede data along with data on morphologically and agriculturally related samples. In the case of leaves, we thus supplemented the beet and swede data with data on cabbage and kale, and for the roots we used potatoes and carrots as a supplement. Under the assumption that all interactions could be neglected, i.e. the ratios between the various species are constant in time for a given location, nuclide and plant part, the VAR-3 calculates the missing figures.

Tables E.1 and E.2 show the estimated figures and tables E.3 - E.6 the anova. It appears that the assumption of no significant interactions is fulfilled in the case of S.U. in roots and probably also for M.U. in leaves. For S.U. in leaves the interaction between species and years is probably significant, but this significance is neglected as it is not very pronounced. In the case of M.U. in roots we cannot test the possible significance of the interaction, and thus, in accordance with the other anova, assume no significant interaction.

In tables E.1 and E.2 the observed values are shown in brackets. Although the differences between the calculated and observed values are conspicuous in some cases, the correlation coefficients for S.U. and M.U. in roots, as well as in leaves, were all significant.

Table E.1

VAR-3 estimated pCi ^{90}Sr/g Ca levels in beets and swedes, 1959-74
(observed levels (cf. 8.6 and Risø Report No. 107[1]) are shown in brackets)

	Beets				Swedes			
	Leaves		Roots		Leaves		Roots	
Year	Jutland	Islands	Jutland	Islands	Jutland	Islands	Jutland	Islands
1959			64	38			42	25
60			81	49			54	32
61			92	55			61	36
62	51	37	105	63	62	45	69	42
63	130 (162)	95 (130)	156 (193)	93 (120)	156	115 (119)	103	62 (90)
64	90 (74)	66	139 (93)	84	109 (88)	80	92 (53)	55
65	77 (66)	56	142 (186)	85	93 (112)	68	94 (76)	56
66	68 (55)	50	154 (122)	92	83	61	107 (150)	61
67	62	45	89	53	75	55	59	35
68	67	49	93	56 (66)	82	60	62	37
69	49	35	147	88	59	43	98	59
70	71	52	147	88 (87)	87	63	97	58
71	66	48	135	81	80	59	89	54
72	62	46	94	67 (44)	76	58	63	38
73	62	38	138	83	64	47	92	55
74	88	64	78	47	107	78	61	31

Correlation coefficients (r) between observed and calculated values:

pCi ^{90}Sr/g Ca in leaves: r = 0.84 (P > 99%)

pCi ^{90}Sr/g Ca in roots: r = 0.73 (P > 99%)

Table E.2

VAR-3 estimated pCi ^{137}Cs/g K levels in beets and swedes, 1963-74
(observed levels (cf. 8.6) are shown in brackets)

	Beets		Swedes	
	Leaves	Roots	Leaves	Roots
1963	68.9 (69)	6.08 (17)	124.0	34.4
64	28.5 (39)	3.51 (8)	51.2 (57)	17.6 (19)
65	17.7 (13)	0.41 (0)	31.8 (29)	2.1 (9)
66	9.1 (7)	1.35 (15)	16.4	6.7 (1.5)
67	4.8	0.31	8.7	1.5
68	10.8	0.40 (1.1)	19.5	2.0
69	9.8	0.43	17.7	2.2
70	4.2	0.55 (0.7)	7.6	2.8
71	5.6	0.23	10.1	1.1
72	6.9	0.05 (0)	12.4	0.3
73	3.3	0.16	6.0	0.8
74	2.5	0.11	4.6	0.5

Correlation coefficients (r) between observed and calculated values:

pCi ^{137}Cs/g K in leaves: $r = 0.98$ ($P > 99\%$)

pCi ^{137}Cs/g K in roots: $r = 0.67$ ($P > 95\%$)

Table E.3

Anova of S.U. in "roots" 1959-74 in Jutland and the Islands (potato, carrot, beet and swede)

Effect	Source of variation	SSD	f	s^2	v^2	P
Main	Years (y)	4.284	15	0.286	3.16	99.9
"	Species (s)	2.636	3	0.879	9.71	99.99
"	Country Part (c)	4.179	1	4.179	46.17	100.00
Interaction	y x s	2.666	20	0.133	1.75	-
"	s x c	0.200	2	0.100	1.31	-
"	y x c	0.499	15	0.033	0.44	-
"	y x s x c	0.763	10	0.076	0.25	-

Table E.4

Anova of S.U. in "leaves" 1959-74 in Jutland and the Islands
(cabbage, kale, beet and swede)

Effect	Source of variation	SSD	f	s^2	v^2	P
Main	Years (y)	2.814	12	0.234	1.76	-
"	Species (s)	4.731	3	1.577	11.82	99.9
"	Country Part (c)	0.937	1	0.937	39.80	99.99
Interaction	y x s	1.467	11	0.133	5.76	96.7
"	s x c	0.001	1	0.001	0.06	-
"	y x c	0.283	11	0.026	1.11	-
"	y x s x c	0.116	5	0.023	0.17	-

Table E.5

Anova of M.U. in "roots" 1963-74 in Denmark
(potato, carrot, beet and swede)

Effect	Source of variation	SSD	f	s^2	v^2	P
Main	Year (y)	44.91	11	4.08	1.21	-
"	Species (s)	11.22	3	3.74	1.11	-
Interaction	y x s	37.12	11	3.37	-	-

Table E.6

Anova of M.U. in "leaves" 1963-74 in Denmark
(cabbage, kale, beet and swede)

Effect	Source of variation	SSD	f	s^2	v^2	P
Main	Year (y)	20.34	11	1.85	10.34	99.9
"	Species (s)	8.62	3	2.87	16.08	99.9
Interaction	y x s	1.61	9	0.18	-	-

ACKNOWLEDGEMENTS

The authors wish to thank Miss Anna Holm Pedersen, Miss Lone Dyrgård Jensen, Mrs. Karen Henriksen, Miss Karen Wie Nielsen, Mrs. Jytte Lene Clausen, Mrs. Ulla Wilhelmsen, Mrs. Anna Madsen, Mrs. Laila Leth, Mrs. Pearl Baade Pedersen, and Mrs. Else Sørensen for their conscientious performance of the analyses. We are grateful to Mr. Peder Kristiansen, Mr. Hans Hansen (deceased), and Mr. Gunnar Bitsch for collection of the samples and performance of the γ-background measurements.

We are specially indebted to the staffs of the eleven State experimental farms at Tylstrup, Ødum, Studsgård, Askov, St. Jyndevad, Blangstedgård, Tystofte, Ledreborg, Virumgård, Abed, and Åkirkeby, who have continued to supply us with a number of the most important samples dealt with in this report.

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ISBN 87 550 0[illegible]